PL 896 Licence status report

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1 History of the production licence

Licence: PL 896

Awarded: 10.02.2017

Licence period: Expires: 10.02.2027
Initial period: 10 years

Licence group:

Equinor Energy AS	30% (operator from 11.02.2022-10.02.2023)
Aker BP ASA	30%
Wintershall DEA Norge AS	20% (operator from 10.02.2017-10.02.2022)
Petoro AS	20%

Licence area: 1146 km²

Work programme: Decision to drill exploration well - 10.02.2018 (completed)
Extension(s) of BoK 10.02.2020-10.02.2024, main reason: finalize ongoing studies and evaluate remaining prospectivity.

Meetings held:

04.05.2017	EC/MC meeting	05.06.2019	EC/MC meeting
05.10.2017	EC/MC meeting	18.09.2019	EC/MC meeting
20.02.2018	EC work meeting	27.11.2019	EC/MC meeting
08.03.2018	EC/MC meeting	06.03.2020	EC meeting
19.06.2018	EC/MC meeting	11.06.2020	EC meeting
04.09.2018	EC meeting	25.11.2020	EC/MC meeting
22.10.2018	EC/MC meeting	10.03.2021	EC meeting
10.12.2018	EC/MC meeting	29.03.2021	EC meeting
15.02.2019	EC meeting	19.11.2021	EC/MC meeting
18.03.2019	EC meeting	20.10.2022	EC/MC meeting

Work performed:

2017:	Prospect evaluation, well planning and risk assessment (Toutatis prospect).
2018:	Well planning (Toutatis prospect).
2019:	Exploration drilling (NO 6611/1-1 Toutatis). Post well evaluation.
2020:	Post well analysis, prospect evaluation, seismic reprocessing.
2021:	Seismic conditioning, prospect evaluation.
2022:	Evaluation of prospectivity.

Reason for surrender:
Equinor and PL896 licence partners have not been able to identify an attractive drilling candidate in the licence. Due to long distance to infrastructure and limited discovered volumes in the area, significant additional volumes are needed to develop future discoveries in the area. The decision to surrender the licence was unanimous.

2 Database

2.1 Seismic data

The common seismic database in the licence consists of a selection of 2D and 3D seismic data (Table 2.1, 2.2, figure 2.1). TB3DM-2012 (ST9404 reprocessing) and EO13002 have been the main datasets for evaluating prospectivity in the licence. During the licence period, EO13002 was reprocessed (EO13002WDR20) by ION and further conditioned by Wintershall DEA to enhance the data quality for the prospective intervals. Detailed prospect evaluation and geophysical studies have utilised a combination of available 3D seismic and vintages (see chapter 3).

2D seismic database (name, NPDID)

ST9293	Site survey	MNR04	4252	SG9304	3615
ST9294	Site survey	N3-94	3665	ST8604	2894
ST9295	Site survey	N6SD-93/94	3598	ST8704	3048
GMNR-94	3650	NH8102	2436	ST9104	3453
MNT-92	3522	NH9706	3863	TBN96	3743
NPD-LOFO-87/88	2997	NPD-ML01-72	2046	TPNE-94	3698
NPD-ML-74/75	2102	NPD-TB-84/87	2650	TBS2000	4075

Table 2.1 2D seismic database.

3D seismic database (name, area, NPDID)

EO13002	950 km²	7854
ST9404	904 km²	3686
WIN12002	1151 km²	7609

Table 2.2 3D seismic database.

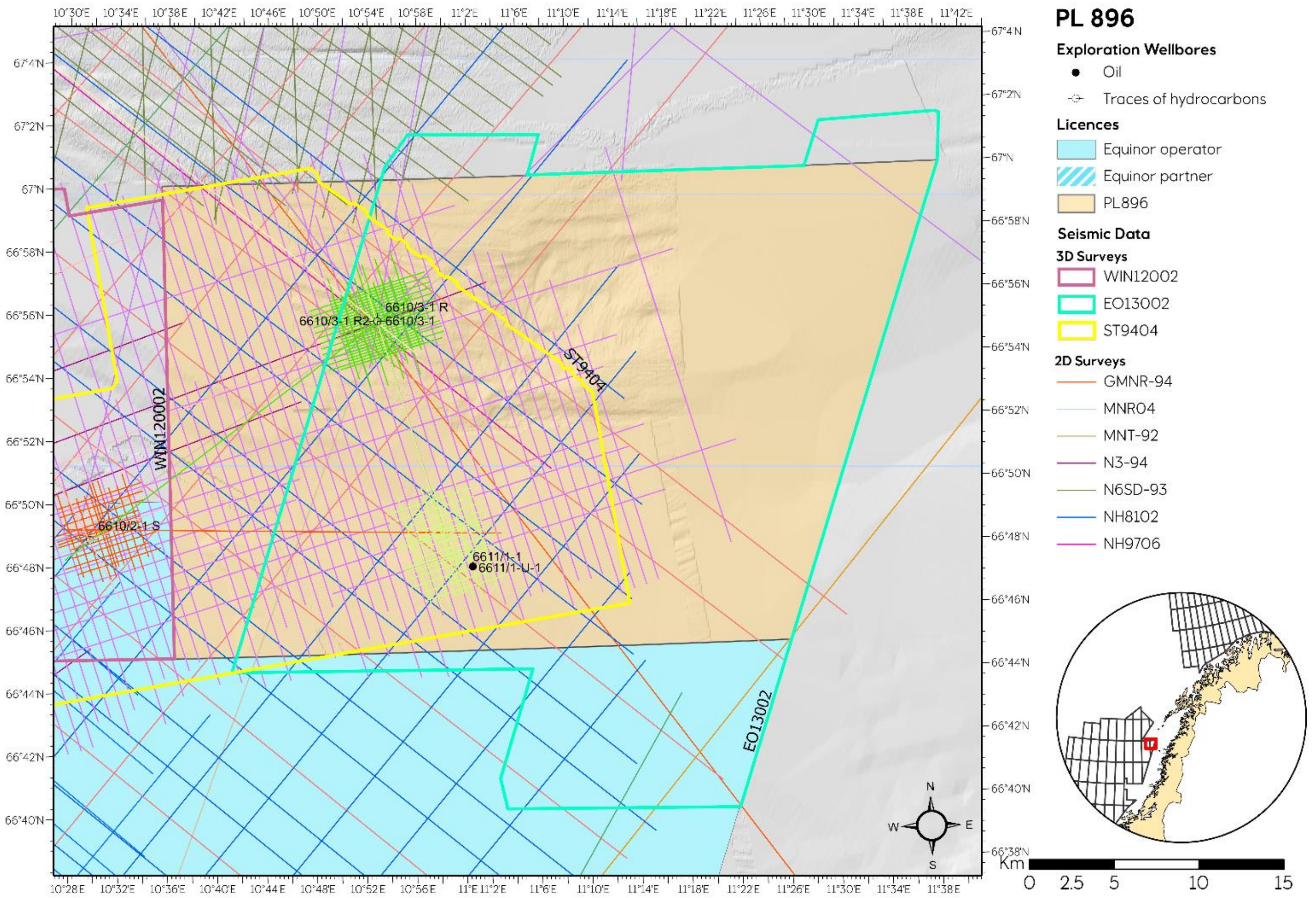

Figure 2.1 2D and 3D seismic database.

2.2 Well data

The common well database comprises publicly available data from released wells listed in table 2.1. The list include well name, NPDID number, completion year, results and formation at TD.

Well	NPDID	Year	Result	Age at TD
6611/1-1	8887	2019	Oil	Triassic
6610/3-1R	1864	1993	Shows	Late Cretaceous
6610/2-1S	2874	1996	Shows	Triassic
6710/10-1	3941	2000	Dry	Late Cretaceous
6610/7-2	26	1984	Dry	Early Triassic
6610/7-1	12	1983	Dry	Late Triassic
6610/10-1	7091	2013	Dry	Late Triassic
6510/2-1R	3263	1997	Dry	Early Triassic
6609/6-1	5626	2007	Dry	Late Triassic
6609/5-1	445	1985	Shows	Middle Triassic
6609/7-1	19	1983	Dry	Permian
6609/11-1	15	1983	Dry	Late Triassic
6609/10-1	24	1983	Dry	Late Triassic
6609/10-2	6188	2009	Dry	Late Triassic
6608/11-4	4939	2004	Oil	Late Triassic
6608/11-2	4189	2000	Oil	Late Triassic
6608/10-12	5949	2008	Oil	Late Triassic

Table 2.2 Well database.

3 Results of geological and geophysical studies

The following geological and geophysical studies were carried out in the licence period:

- NO 6611/1-1 Toutatis post-well studies.
- Seismic reprocessing and conditioning.
- AVO inversion and 2D forward modelling.
- Spectral decomposition analysis.
- Hydrocarbon migration studies.

3.1 NO 6611/1-1 Toutatis post-well studies

A range of studies were initiated following the completion of 6611/1-1 to resolve the properties of the reservoir and associated fluids including RCA, SCAL, Biostrat, Mineralogy, Geochem and PVT. The well encountered a ~10m oil column in the Pliensbachian Tilje Formation, confirmed by pressure, fluid scanning and sampling. Due to the proximity to the free water level (FWL) hydrocarbon saturation in the reservoir is low and decreases towards the FWL. No conventional core was taken, however extensive log, MDT and sidewall cores were collected and forms the basis for the performed post-well studies.

Digital scanning of sidewall cores**:**

To supplement the performed special core analysis (SCAL) on sidewall cores from 6611/1-1, digital scanning of a selection of core data was performed at Wintershall DEA's technology centre. The main aim of this analysis was to calibrate and reduce the uncertainty in cementation exponent (m) and saturation exponent (n) derived from SCAL. Results show a moderate deviation in electrical properties compared to results from the SCAL. This could indicate a slightly lower water saturation in the reservoir compared to SCAL results. Final results from this study are pending.

Fluid substitution modelling and AVO:

A relatively uniform and thick mudstone (soft acoustic impedance) is seen to overly the Tilje Formation in the Toutatis area. As a result, fluid substitution modelling shows a hard top reservoir response on near angles in all fluid scenarios, dimming with offset. Given the low hydrocarbon saturation and heterogeneous reservoir proven in the well the oil effect is not expected to be clearly visible on seismic data.

The AVO class definition for Tilje Formation is dependent on the overlying rock. Sand response is seen to vary from Class I (oil and brine) to IIP (gas) in the upper part of the reservoir to class IV-III in the lower parts of the reservoir. In both cases base of sand is seen as a hard response (increasing acoustic impedance) on near angles increasing with offset when hydrocarbon filled. A weak base reservoir response is expected for brine.

3.2 Seismic reprocessing and conditioning

Following the 6611/1-1 Toutatis discovery seismic reprocessing of the legacy EO13002 was initiated with a goal of improving the seismic imaging below the Base Cretaceous Unconformity (BCU) to de-risk Jurassic prospectivity. To achieve increased seismic resolution the following objectives were defined:

- Bandwidth broadening by de-ghosting and computation/application of Q compensation.
- Efficient attenuation of multiples and other dipping noise of gathers for seismic reservoir characterization.
- Generation of an accurate PSDM velocity model.
- Improvements to fault imaging.

Two sets of reprocessed deliverables were created:

- Data from the processing contractor (Ion GXT).
- Data from Wintershall DEA (Operator) with alternative post-migration pre-stack conditioning.

Together with the legacy EO13002, the reprocessed and conditioned data have formed the basis for subsequent prospect evaluation in the licence following the Toutatis discovery.

3.3 AVO inversion and 2D forward modelling

To assess the remaining prospectivity in the licence following the Toutatis discovery, Equinor has performed AVO inversion on all available vintages of the EO13002 3D seismic dataset. The workflow includes phase rotation, bandwidth matching, relative impedance and time alignment, outputs lithology and fluid volumes based on extended elastic impedance CHI angle rotations. The legacy EO13002 dataset is seen to yield the most stable AVO responses and has been the preferred volume to evaluate variations in lithology and hydrocarbons presence in the identified prospects.

For the Cretaceous prospectivity (see chapter 4.2) 2D forward modelling was performed to assess possible combinations of reservoir properties, facies variations and fluid variations against the AVO evaluation of the prospect. The combination of AVO observations and 2D modelling has proven useful to quality assess the results.

3.4 Spectral decomposition analysis

Spectral decomposition analysis was performed to investigate the depositional character of the Lange Formation sandstones within the license area. The spectral decomposition was visualized by using RGB blends extracted from iso proportional slices within the Cretaceous interval. The RGB blends provide an improved image of the different sand feeder systems through Vestfjorden Basin and Grønøy Canyon. The RGB blends were also used for understanding the depositional model for the Revheim prospect reservoir, distribution of lobes and channel/lobe connectivity.

3.5 Hydrocarbon migration studies

Migration scenario modelling was performed to model and de-risk alternative migration routes into the Toutatis area and adjacent prospects (see chapter 4.1). The main inputs to the performed study were alternative Top Tilje Formation (Base Toarcian) horizons as a vertical restriction to flow, and fault interpretations as possible lateral barriers to flow. A combination of scenarios was tested with selected faults open/closed and variations in charge seed points in the basin. The results gave insight into potential key barriers for migration, and a polarised migration risk evaluation for the remaining Jurassic prospects in the Toutatis area (see chapter 4.1.2)

4 Prospect update report

The prospectivity in PL896 is primarily associated with lower-middle Jurassic structural traps on the northern margin of the Nordland Ridge, down-dip of the Toutatis discovery, and Cretaceous structural/stratigraphic traps in the Vestfjorden Basin. The evaluation of remaining prospectivity in the licence has integrated the re-processed seismic data and results from 6611/1-1 post well studies. A summary of volume and risk from the application for award is given in table 4.1.

Discovery/ Prospect/Lead name	D/ P/ L	Case (Oil/ Gas/Oil &Gas)	Unrisked recoverable resources						Probability of discovery (0.00 - 1.00)	Reservoir	
			Oil [10^6Sm^3]			Gas [10^9Sm^3]				Litho-/ Chrono-stratigraphic level	Reservoir depth [m MLS]
			Low (P90)	Base (Mean)	High (P10)	Low (P90)	Base (Mean)	High (P10)			
Toutatis	P	Oil&Gas	3.92	38.43	90.77	0.15	2.4	5.7	0.27	Åre + Tilje Fms. Lower Jurassic	1270
Esus	P	Oil&Gas	3.68	26.72	61.05	0.15	0.54	3.86	0.25	Åre + Tilje Fms. Lower Jurassic	1650
Cernunnos	P	Oil&Gas	1.87	14.01	32.13	0.07	0.84	2.02	0.25	Åre + Tilje Fms. Lower Jurassic	1850
Belenos	P	Oil&Gas	1.14	8.32	19.11	0.04	0.47	1.11	0.25	Åre + Tilje Fms. Lower Jurassic	1250
Borvo	L	Oil&Gas	1.8	11.52	25.55	0.07	0.43	2.03	0.22	Åre + Tilje Fms. Lower Jurassic	1600
Clipper	L	Oil	2.55	10.80	22.40	1.1	5.44	11.7	0.19	Melke Fm. Upper Jurassic	3150
Rodussen	L	Oil	4.9	12.60	28.40	0.23	0.76	2.03	0.17	Nise Fm. Campanian	2060
Rakflesa	L	Oil	4.2	6.72	10.43	0.2	0.4	0.82	0.13	Tang Fm/Paleocene	1582

Table 4.1 Summary of volume and risk from application for award.

4.1 Jurassic

At the time of award, the Jurassic Toutatis prospect was the main target in the licence (Fig. 4.1). Following the discovery in Toutatis, three Jurassic prospects have been evaluated: Esus, Cernunnos and Belenos. A summary of the discovery and the main geological risk elements for the remaining prospects at time of licence surrender are described below and summarized in table 4.2.

4.1.1 Toutatis

6611/1-1 encountered approximately 130 m gross reservoir in the Tilje Formation deposited in a marginal- to shallow-marine (delta front to shoreface) setting. The reservoir consists of very fine to medium grained sandstones with claystone and occasional coal interbeds yielding a net-to-gross of 83 % with an average porosity of 21 %. NMR data acquired on wireline show only a small degree of clay/capillary bound water in the Tilje Formation, indicating that most of the measured porosity is effective with limited bound fluid.

The Toutatis container is defined as a three-way structural trap truncated by base Cretaceous unconformity (top seal) and bounded by faults towards northeast and south. Apex of the structure is set to 1183 m TVDSS and the FWL is interpreted at 1236 m TVDSS giving a total hydrocarbon column of 53 meter with some uncertainty. Several explanations have been investigated to determine what controls the hydrocarbon-water contact (HCWC). These include charge limitation, retention capacity (top seal) and lateral (juxtaposition) seal limitations.

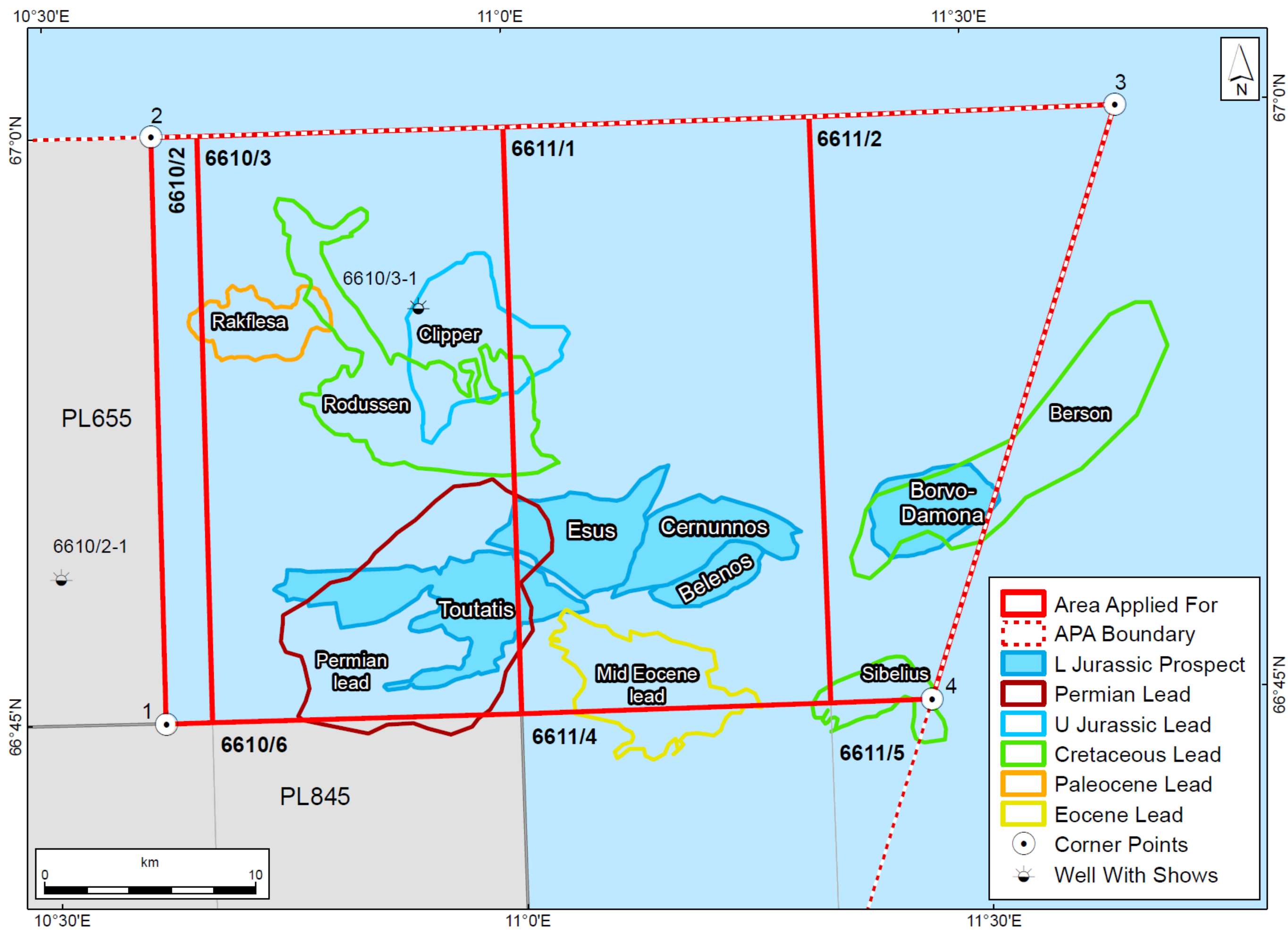

Figure 4.1 Overview map with area applied for and the main prospects and leads at time of application for award.

For calculations of proven volume, the reservoir properties from 6611/1-1 have been used with restricted spread on key input parameters. The main uncertainty in the reserve calculations is attributed to the oil saturation uncertainty (see chapter 3.1). As the low saturations observed in the well are believed to reflect proximity to FWL, oil saturation applied in the reserve calculation is therefore derived from a hydrocarbon column height function. This calculates a maximum oil saturation of 83 % at apex, which is aligned with the highest mobile liquid fraction derived from the NMR log. The resulting calculations indicate an expected 1.13 MSm³ recoverable oil in the Toutatis discovery.

4.1.2 Remaining Jurassic prospectivity

The remaining Jurassic prospectivity is primarily represented by untested structures down-dip of the Toutatis discovery (Fig 4.2). The main geological risk elements are described below and summarized in table 4.2.

Reservoir:

The evaluated reservoir interval is the Tilje Formation which has been closely calibrated to results from 6611/1-1 with only minor adjustments to correct for variations in depth and maximum burial. No risk is therefore attributed to finding a working reservoir in these prospects.

Trap:

The Esus and Cernunnos prospects are mapped as down-faulted 3-way traps, down-dip from the Toutatis discovery. Unlike Toutatis which has Jurassic reservoir juxtaposed to older Triassic strata on the Nordland Ridge, Esus and Cernunnos are juxtaposed against Jurassic reservoirs (Fangst and Båt Gp.). This introduces a slightly higher risk on seal with increased risk of cross-fault leakage where there is sand-sand juxtaposition. The Belenos prospect is interpreted to be in a similar trap configuration to Toutatis (Fig. 4.3).

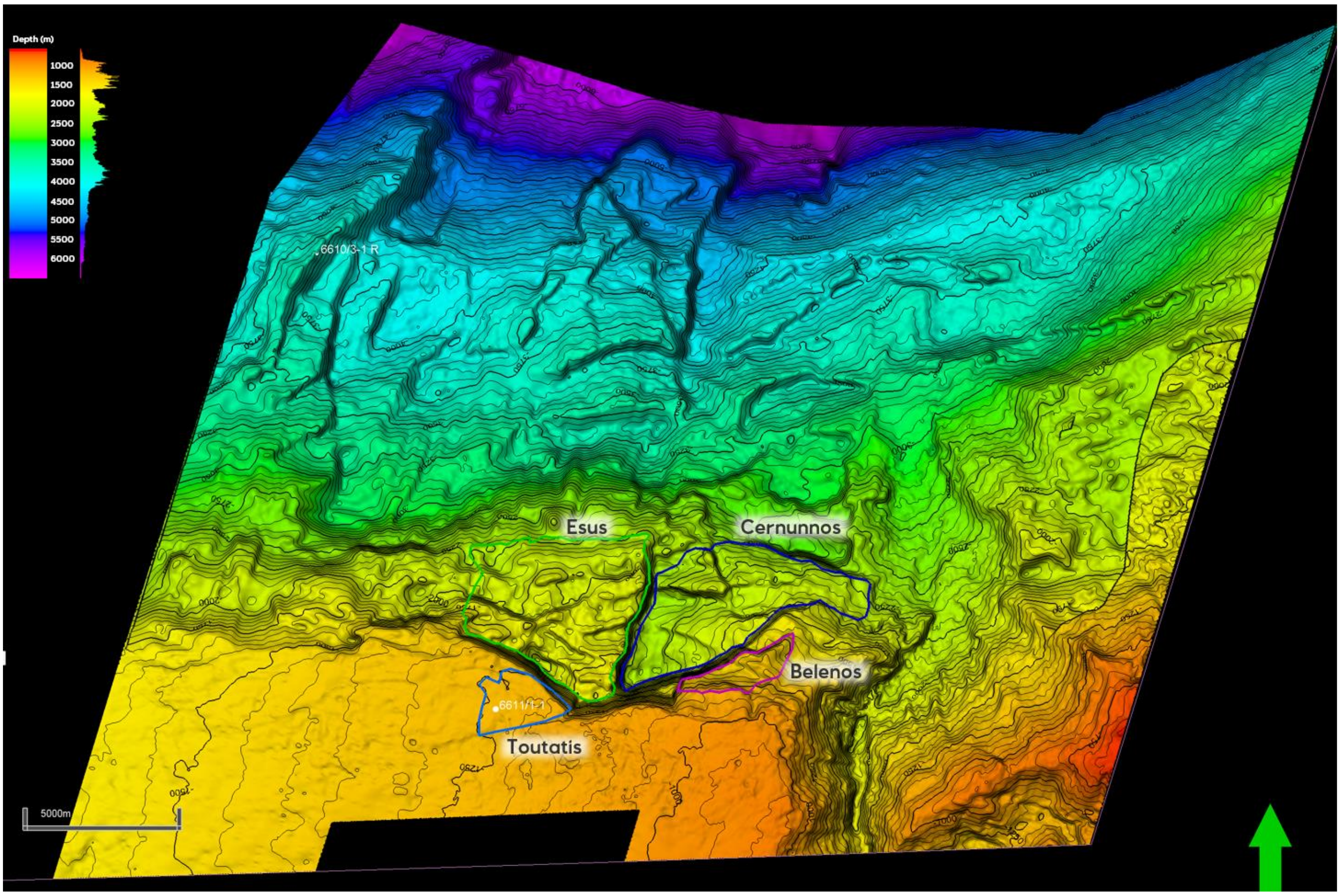

Figure 4.2 Top Tilje Fm. depth map showing the location of evaluated Jurassic prospects.

Migration:

The 6611/1-1 Toutatis discovery proved the source model in the Vestfjorden Basin and migration onto the Nordland Ridge. To polarize the migration risk for the remaining Jurassic prospects a scenario modelling was performed with focus on migration in Jurassic carrier beds. The study showed that of the three evaluated opportunities, the Esus prospect was the most likely to receive charge from a Spekk Formation source regardless of potential fault barriers. The modelling exercise also showed that the Cernunnos prospect could be in a migration shadow and therefore less likely to receive charge through migration below base Cretaceous unconformity. The Belenos prospect could be dependent on a more easterly fetch area in the Vestfjorden Basin.

<ins>Seismic and AVO:</ins>
Carried out fluid replacement modelling on well 6611/1-1 to understand reservoir presence and increased understanding of lateral facies variations, properties and fluid phase. Various AVO volumes has been used to map out the Jurassic sandstones which is mainly of AVO class IV type.

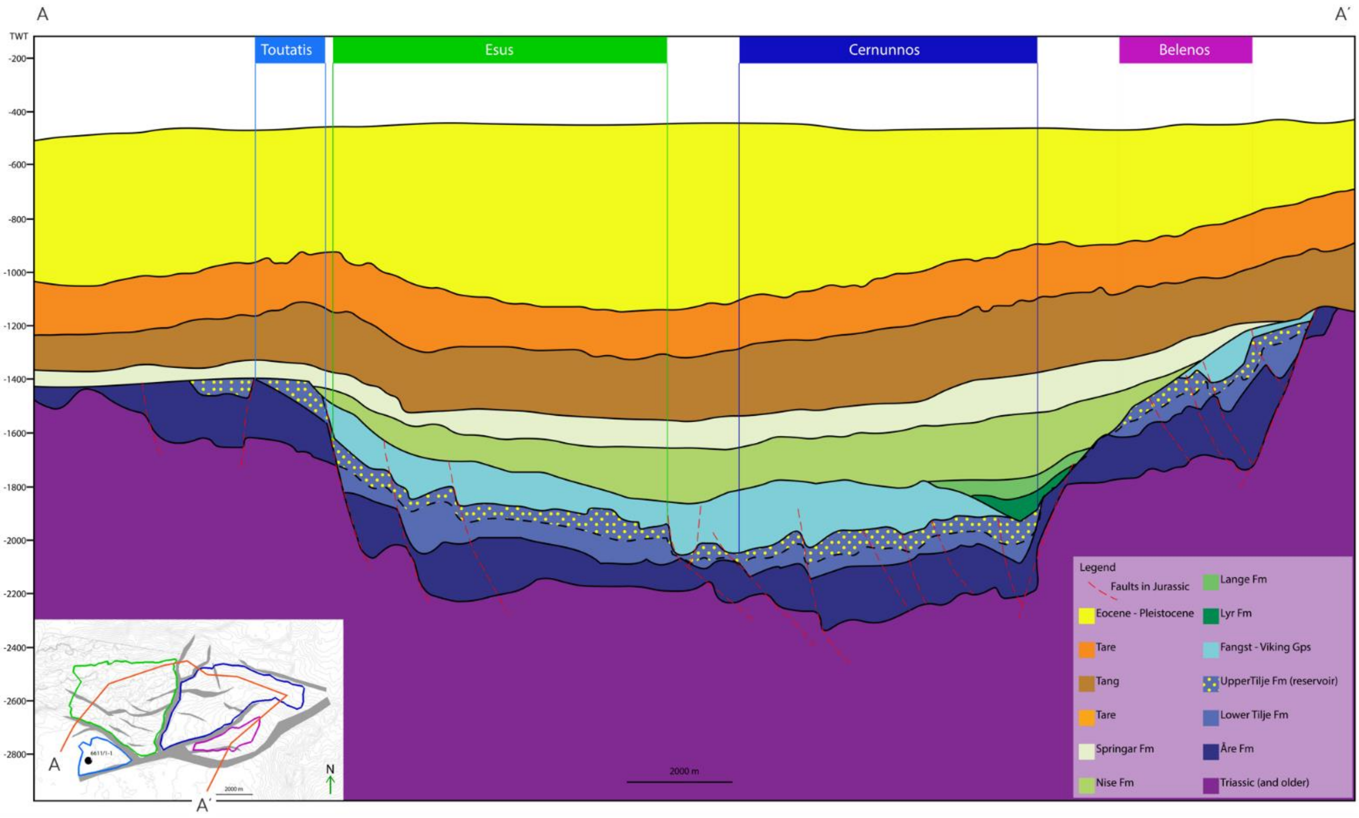

Figure 4.3 Geoseismic section through Jurassic prospects near Toutatis.

4.2 Cretaceous prospectivity

In the licence period, three Cretaceous prospects have been evaluated: Revheim and Langeåra (Fig. 4.4) within the Lange Formation, and Jektvik within the Nise Formation (Fig. 4.5). The main geological risk elements are described below and summarized in table 4.2.

<ins>Reservoir:</ins>
The reservoirs associated with the Cretaceous prospects in the licence are represented by channel-lobe complexes sourced from the Grønøy High (south) and mainland Norway (east). In the Lange Formation, Cenomanian sand influx can be inferred from seismic amplitude maps mostly as single cycle events. In some areas, differential compaction can be seen in combination with convex overburden geometries indicating thicker sandstone intervals. The Revheim and Langeåra prospects show thicknesses above tuning (18 m) with differential compaction indicating presence of high net to gross reservoirs. Towards the margins of these systems, reservoir sands are within tuning, making it difficult to accurately resolve thicknesses and pinch-out. The amplitude maps and RGB blends indicate that the Grønøy High fairway (N-S

trending) links up with the larger E-W trending fairway from Vestfjorden. Well 6610/3-1R tests the mapped sand fairway in Vestfjorden Basin and encountered multiple reservoir intervals within the Cretaceous.

The Jektvik prospect is defined by a large submarine fan system observed in the Early Campanian Nise Formation. A 40 m thick sandstone unit was encountered in the nearby well 6610/3-1R (off axis), proving reservoir presence and quality.

Trap:
Common for the evaluated Cretaceous opportunities is a stratigraphical trap component towards apex, along axis of reservoir deposition. Seismic mapping of faults and facies variations on variance, AVO and Thin Fault Likelihood volumes (see chapter 3) have been used to evaluate the up-dip trap risk for the Cretaceous prospects. These trap configurations are however inherently associated with higher risk and is considered the main risk for the Cretaceous prospects at the time of licence surrender. In addition to the stratigraphic trap component, several sands are present within the Lange Formation which could represent potential thief sands. The mapped sands are however seen on seismic data as passive onlaps above the prospective intervals with limited to no erosion. Outside the mapped sand fairways, the Cretaceous stratigraphy consists mostly of claystone, proven by wells in the area. Several potential top and base seals are proven by well 6610/3-1R located within the fairway axis out of Vestfjorden Basin.

Migration:
Hydrocarbons are likely to migrate locally from the Spekk Formation source rock in the Vestfjorden Basin into the Cretaceous prospects of the licence area. Hydrocarbon shows are observed in several Cretaceous sandstone levels in well 6610/3-1R. Shallow gas anomalies, pockmarks and sea surface slicks also indicate an active petroleum system. Lateral migration within the Cretaceous fairways is considered likely. In addition to Spekk Formation, an alternative model could be longer distance migration from potential Cretaceous source rocks in the adjacent Træna Basin.

Seismic and AVO:
Offset seismic stacks, AVO, fluid replacement modelling and 2D seismic modelling was applied in the evaluation of Cretaceous prospectivity to investigate reservoir presence and increased understanding of lateral facies variations, properties and fluid phase. Cretaceous sandstones were mapped out in details based on AVO volumes.

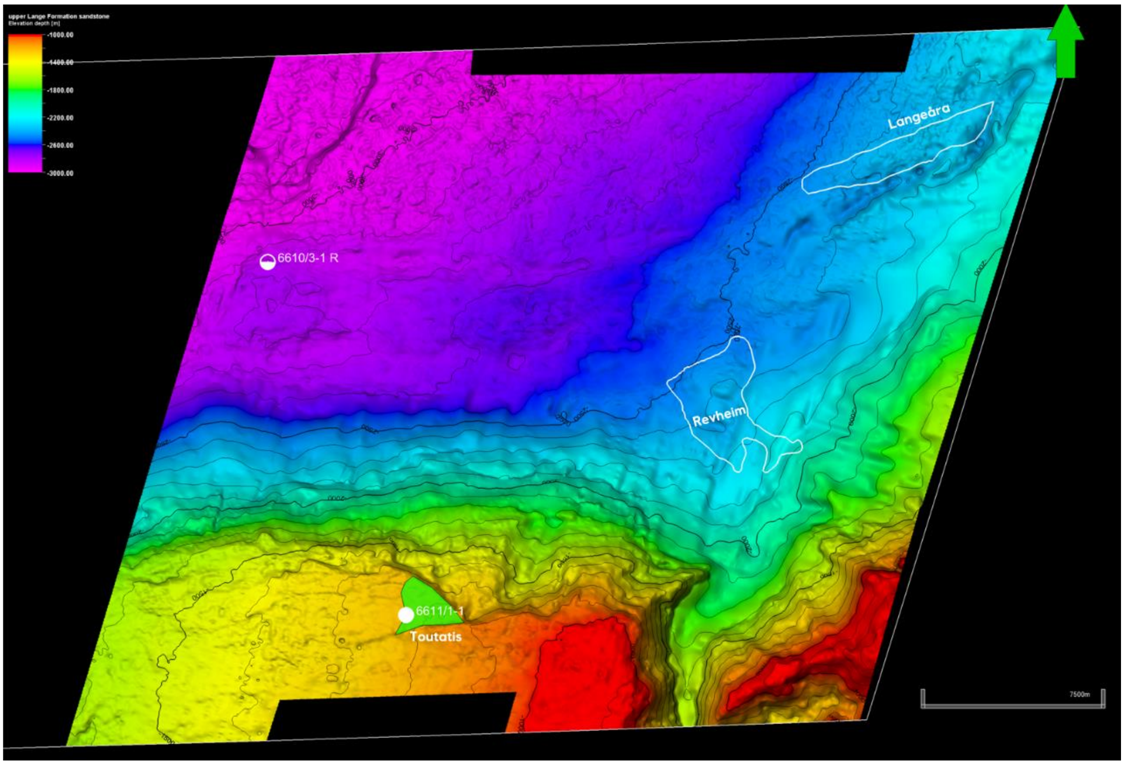

Figure 4.4 Intra Lange Fm sandstone depth map. The location of the Revheim and Langeåra prospects is indicated.

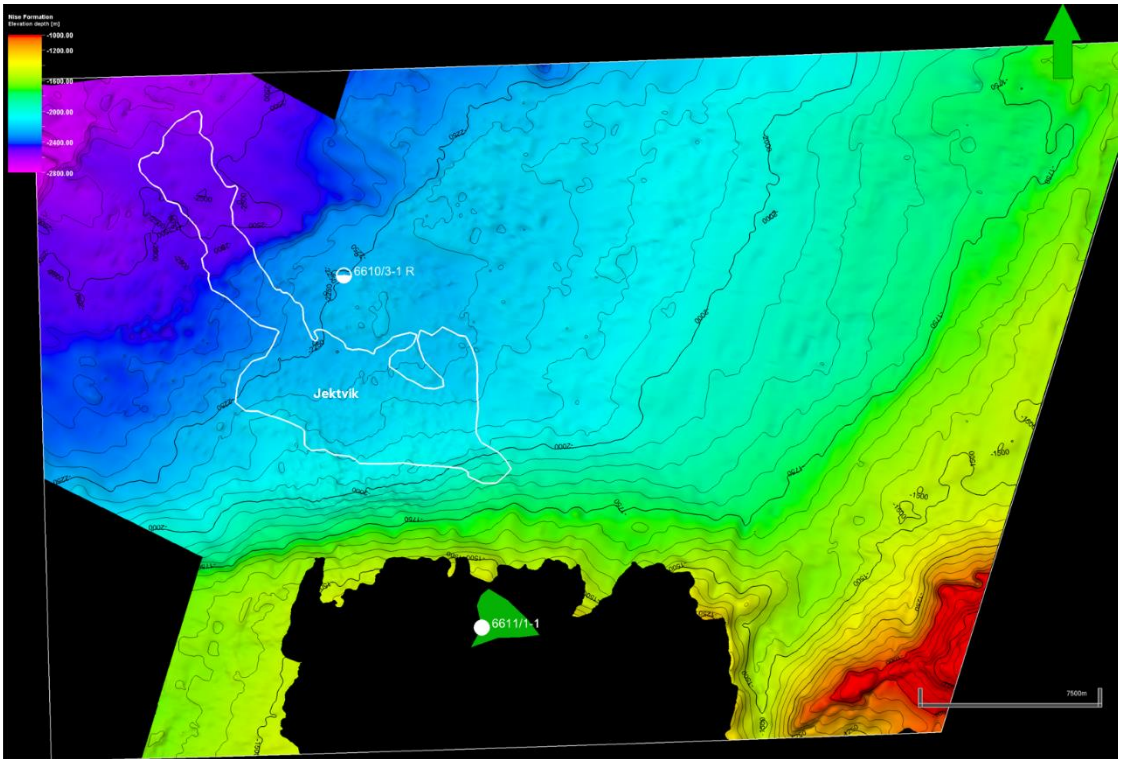

Figure 4.5 Nise Fm depth map. The location of the Jektvik prospect is indicated.

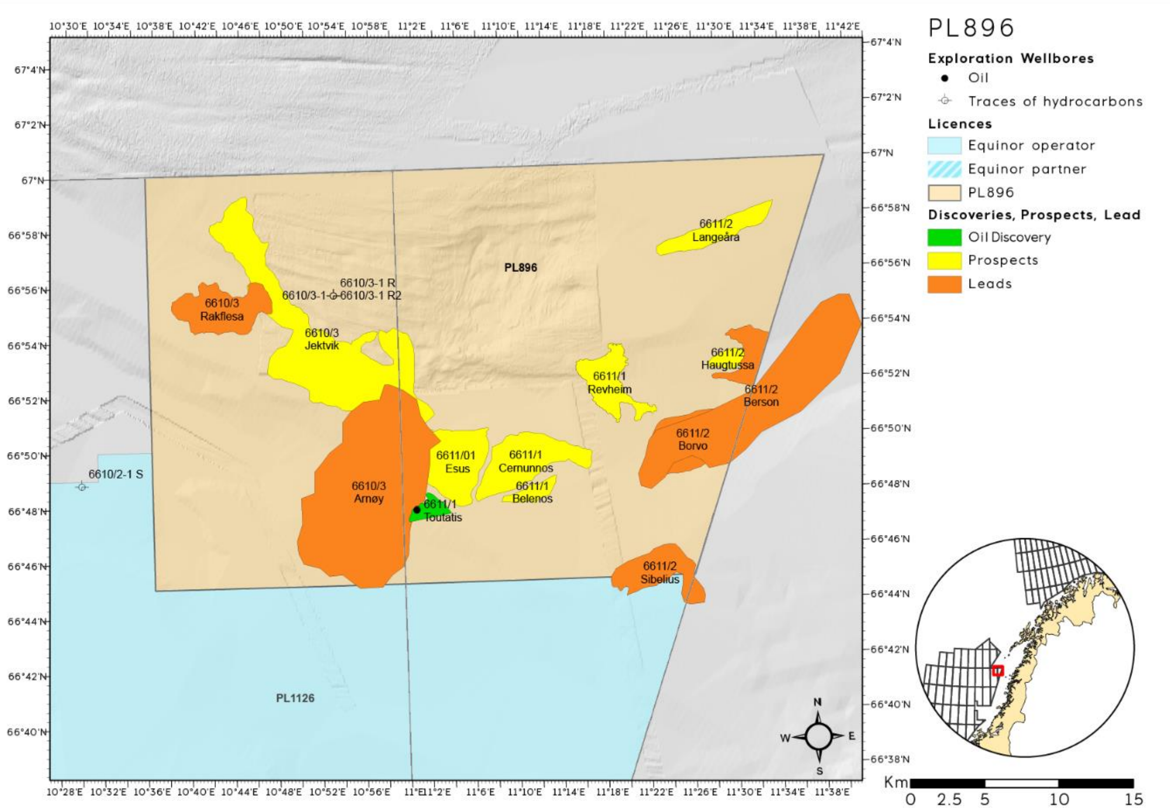

Figure 4.6 Mapped prospectivity at time of licence surrender.

Discovery/ Prospect/Lead name	D/ P/ L	Case (Oil/ Gas/Oil &Gas)	Unrisked recoverable resources						Probability of discovery (0.00 - 1.00)	Reservoir	
			Oil [10^6Sm^3]			Gas [10^9Sm^3]				Litho-/ Chrono-stratigraphic level	Reservoir depth [m MLS]
			Low (P90)	Base (Mean)	High (P10)	Low (P90)	Base (Mean)	High (P10)			
Toutatis	D	Oil	0.87	1.13	1.46	0.03	0.05	0.07	1.00	Tilje Fm/Jurassic	1185
Esus	P	Oil	3.93	13.70	31.10	0.18	0.62	1.39	0.20	Tilje Fm/Jurassic	1600
		Gas	0.10	0.34	0.78	2.59	8.53	19.40	0.08		
Jektvik	P	Oil	0.61	5.61	16.10	0.04	0.35	0.98	0.13	Nise Fm/Cretaceous	1860
Langeåra	P	Oil	2.75	5.53	8.45	0.17	0.34	0.52	0.14	Lange Fm/Cretaceous	2710
Cernunnos	P	Oil	0.98	6.02	14.60	0.15	0.90	2.17	0.16	Tilje Fm/Jurassic	1890
		Gas	0.03	0.19	0.46	0.64	3.88	9.27	0.07		
Revheim	P	Oil&Gas	1.57	3.67	5.95	0.27	0.58	0.94	0.33	Lange Fm/Cretaceous	2060
Belenos	P	Oil	1.12	3.32	6.04	0.16	0.50	0.90	0.13	Tilje Fm/Jurassic	1140
		Gas	0.02	0.05	0.08	0.59	1.70	3.00	0.06		
Haugtussa	P	Oil	0.70	1.39	2.17	0.04	0.09	0.14	0.22	Rogn Fm/Jurassic	2100
Haugtussa Lead	L									Rogn Fm/Jurassic	2100
Borvo	L									Tilje Fm/Jurassic	1600
Berson	L									Nise Fm/Cretaceous	1150
Sibelius	L									Nise Fm/Cretaceous	950
Rakflesa	L									Tang Fm/Paleocene	1580
Arnøy	L									Permian	3700

Table 4.2 Summary of volume and risk for discoveries, prospects and leads at the time of licence surrender.

5 Technical assessment

Full technical assessment was part of the pre-drill evaluation of the Toutatis prospect with a development solution including a stand-alone Floating Production Storage and Offloading (FPSO) facility. The Toutatis discovery and remaining prospectivity in the licence is located c. 150 km northeast of the Norne Field, which is the closest infrastructure in the Norwegian Sea. Any new development in the licence area therefore needs a significant resource basis to be commercially interesting. Following the post-well studies on Toutatis and evaluation of remaining prospectivity in the licence, the remaining prospects does not carry sufficient resource potential for a robust field development in the licence area.

6 Conclusions

Well, 6611/1-1 did not prove sufficient resources to proceed with a field development in the licence. The PL896 partnership has not been able to identify an attractive drilling candidate in the licence and therefore unanimously decided to surrender the area.