PL861

Relinquishment Report

Table of Contents

List of Figures

List of Tables

1 LICENCE HISTORY

1.1 Licence Owners

The PL861 licence owners :

Operator: Aker BP ASA (50%)

Partners: Spirit Energy Norway AS (30%) & MOL Norge AS (20%)

1.2 Award and Work Program

Production licence 861 was awarded in APA2016 on the 10.02.2017 with a drill decision within 2 (two) years and an initial period of seven (7) years. The licence area covers part of the block 2/6, as seen in **Fig. 1.1**

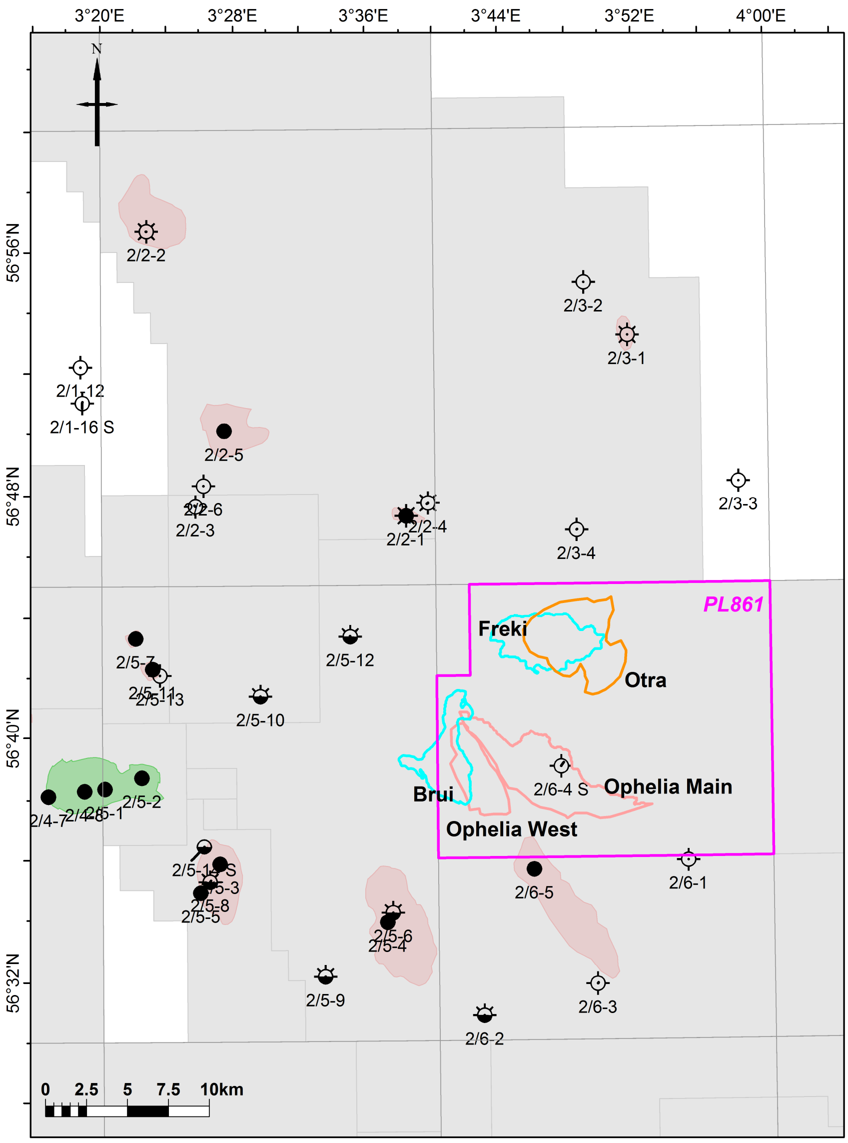

Fig. 1.1 PL861 licence area with outline of prospects and lead

The initial partners in the license were Aker BP ASA (50% and operator), Centrica Resources (Norge) AS (30 %) and MOL Norge AS (20 %). In December 2017 Centrica Resources (Norge) AS changed name to Spirit Energy Norge AS and in December 2018 Spirit Energy Norge AS transferred name to Spirit Energy Norway AS.

The licence was awarded with an initial period of seven years. The work commitment was to acquire 3D seismic data and conduct geological & geophysical studies leading to a drill-or-drop decision after two years. However, one-year extensions to the drill-or-drop decision gate was applied for and subsequently granted six month by the Ministry. The current licence decision to drill deadline was 10^{th} August, 2019.

During the licence period, ten EC and/or MC meetings were held by the operator to share and discuss prospectivity evaluations with the licence partners. In addition to these meeting, a core workshop and licence field trip were organized by the operator.

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

1.3 Identified Prospectivity

PL861 is located north of the Mandal High on a structural hinge line separating the Søgne Basin from the Steinbit Terrace (Fig. 1.2).

Four prospects and one lead have been identified: Upper Jurassic Freki Prospect and Brui lead, Permian Ophelia Main and Ophelia West and Paleocene Otra (Fig. 1.1). The main prospect Freki, is a salt induced four-way dip closure in the Ula Formation. The identified prospects in the licence have charge and reservoir presence as shared risks. These two critical risk factors are common themes throughout the greater Mandal High area.

Marginal resource potential and high risk prospectivity, makes it infeasible to take a drill decision. Therefore, a decision was taken to drop PL 861.

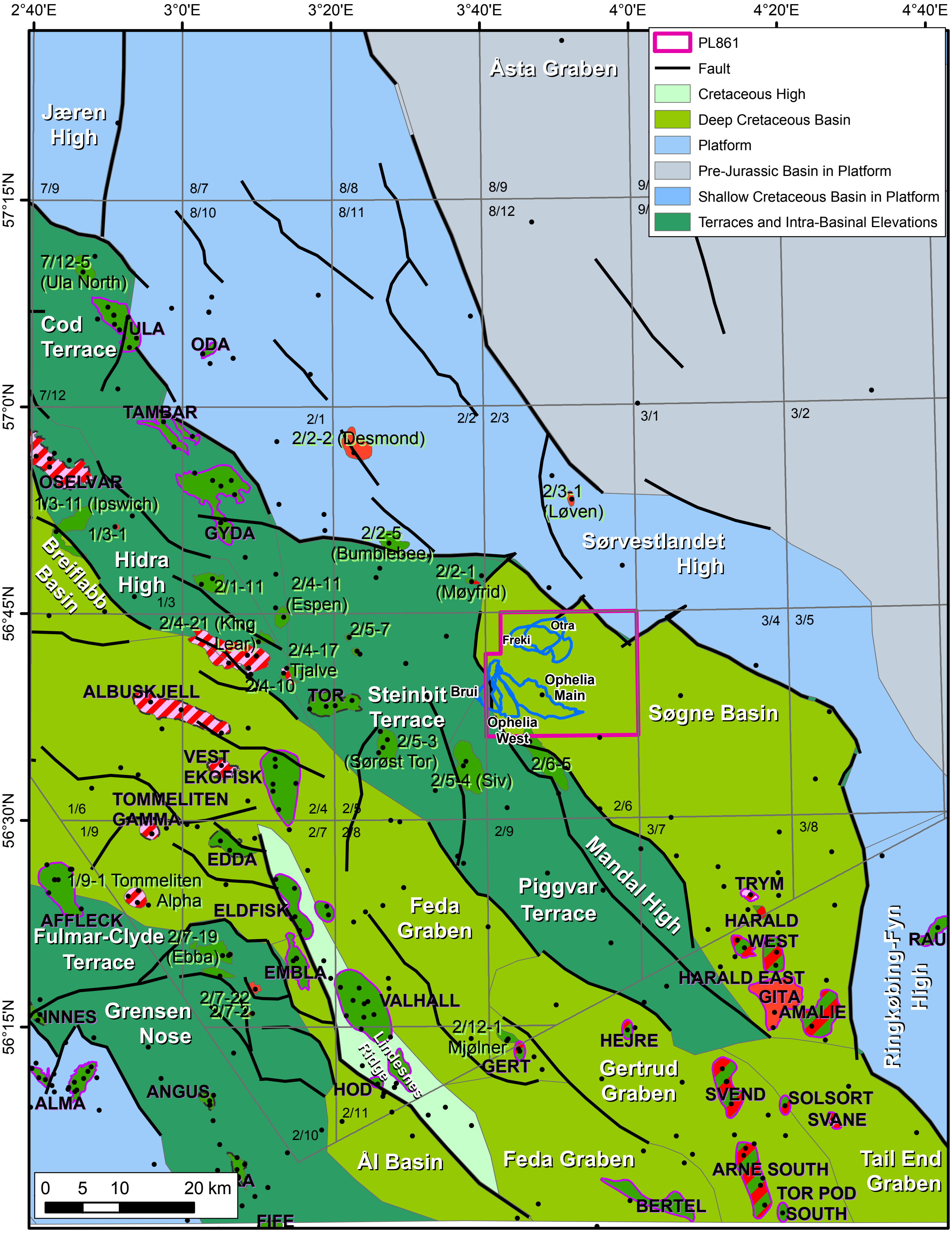

Fig. 1.2 Structural elements map

2 DATABASE

2.1 Seismic Database

The seismic database outline agreed in the licence is shown in Fig. 2.1 and listed in Table 2.1. Subsequent to the award of PL861, the partnership agreed to purchase 618 km^2 of PGS MC3D-CGR2015M multi-client data and reprocessing of this dataset was performed by PGS, named CGRN2013ABPR17.

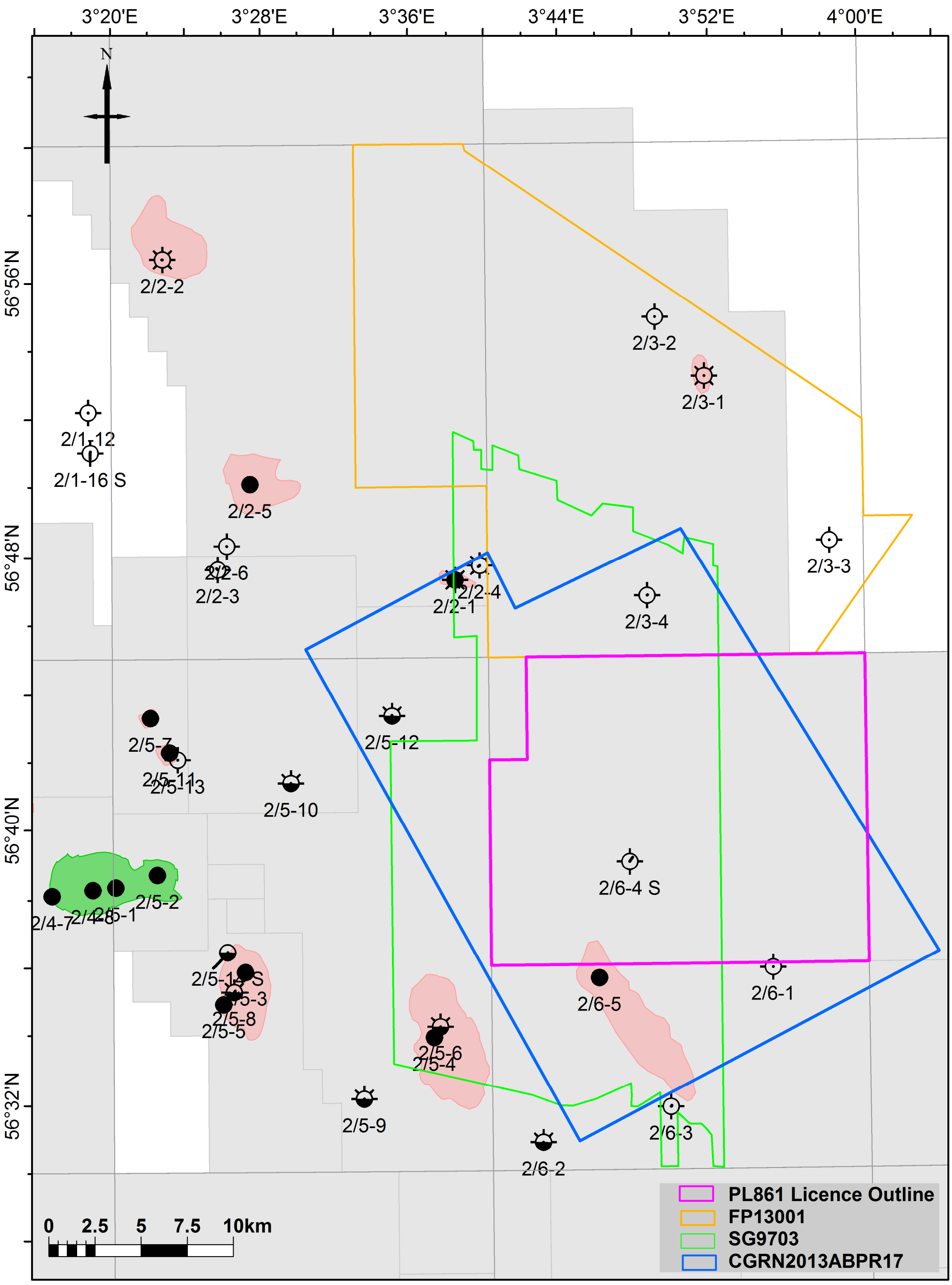

Fig. 2.1 Seismic database overview

Table 2.1 Seismic data list

Survey Name	Vintage	Company	NPD/Diskos survey ID	Public
MC3D-CGR2015M*	2015	PGS MC	10085391125	No
MC3D-CGRN13ABPR17*	2017 reprocessed	AkerBP/PGS	7904	No
SG9703	1997	Saga / Digicon	3872	Yes
FP13001	2013	Faroe / Polarcus	7849	Yes

** Purchased and reprocessed area 618 sqkm*

CGRN2013ABPR17 dataset mainly has been used for licence detailed prospectivity evaluation and inversion study.

2.2 Well Data

The reference exploration wells directly included in geological and geophysical studies are listed in Table 2.2 and shown on the map Fig. 2.2 .

Table 2.2 Well database

Well	Total Depth MD (m)	Drilling Operator	NPDID	Status	Year	Key wells
1/3-5	4850	Shell	223	dry	1985	
2/1-7	5464	BP	137	dry	1985	
2/1-12	3550	BP	3648	dry	1999	
2/1-15	3554	Det norske	7219	dry	2013	
2/1-16 S	3891	Talisman	7180	dry	2013	
2/2-1	4003	Saga	46	oil/gas	1982	x
2/2-3	4100	Saga	3	dry	1983	
2/2-4	4020	Saga	1188	gas	1985	x
2/2-5	4082	Saga	1846	oil	1992	x
2/3-1	2934	Murphy Oil	162	gas	1969	
2/3-3	2973	Murphy Oil	198	dry	1971	
2/3-4	3386	Gulf	129	dry	1984	x
2/4-17	5258	Phillips	1792	gas/condensate	1992	
2/4-20	5719	ConocoPhillips	5556	dry	2008	
2/4-22 S	4889	Statoil	7535	oil	2015	x
2/5-4	3490	Amoco	259	oil	1972	
2/5-6	4132	Amoco	261	oil/gas shows	1978	
2/5-9	5460	Amoco	1834	oil shows	1992	
2/5-10 A	4715	Agip	2194	oil shows	1993	
2/5-12	4153	Amerada Hess	4433	oil shows	2002	
2/5-14 S	3845	Lundin Norway AS	5958	oil shows	2009	
2/6-1	3366	Elf	160	dry	1969	
2/6-2	4760	Elf	224	oil shows	1980	
2/6-3	4060	Elf	64	dry	1983	
2/6-4S	3617	Elf	1527	dry	1990	x
2/6-5	3260	Saga	2885	oil	1997	x
2/6-6 S	3843	MOL Norge AS	8560	dry	2019	
2/7-2	3964	Phillips	187	oil	1971	
2/7-20	4509	Phillips	1062	oil	1988	
2/7-31	4968	Phillips	3573	oil	1999	
2/9-2	4367	Amoco	283	dry	1979	
2/9-3	4859	Amoco	1443	oil shows	1989	
2/9-4	5500	ConocoPhillips	5801	dry	2008	
2/9-5 S	3679	Det norske	7502	dry	2014	
2/10-1 S	4609	Phillips	284	gas shows	1976	
3/4-1	3107	Amoco	2222	dry	1994	
3/5-1	3426	Gulf	290	dry	1978	x
3/5-2	3825	Gulf	291	dry	1978	
3/7-2	4330	Elf	220	dry	1981	
3/8-1	4070	Lundin	6476	dry	2010	
7/12-5	4440	BP	299	oil	1981	
7/12-10	3667	BP	1557	oil shows	1991	
7/12-11	3868	BP	1787	shows	1991	
8/10-3	5738	ConocoPhillips	6098	dry	2010	x
8/10-4 S	3071	Centrica	6630	oil	2011	
8/10-4A	3639	Centrica	6737	dry	2011	

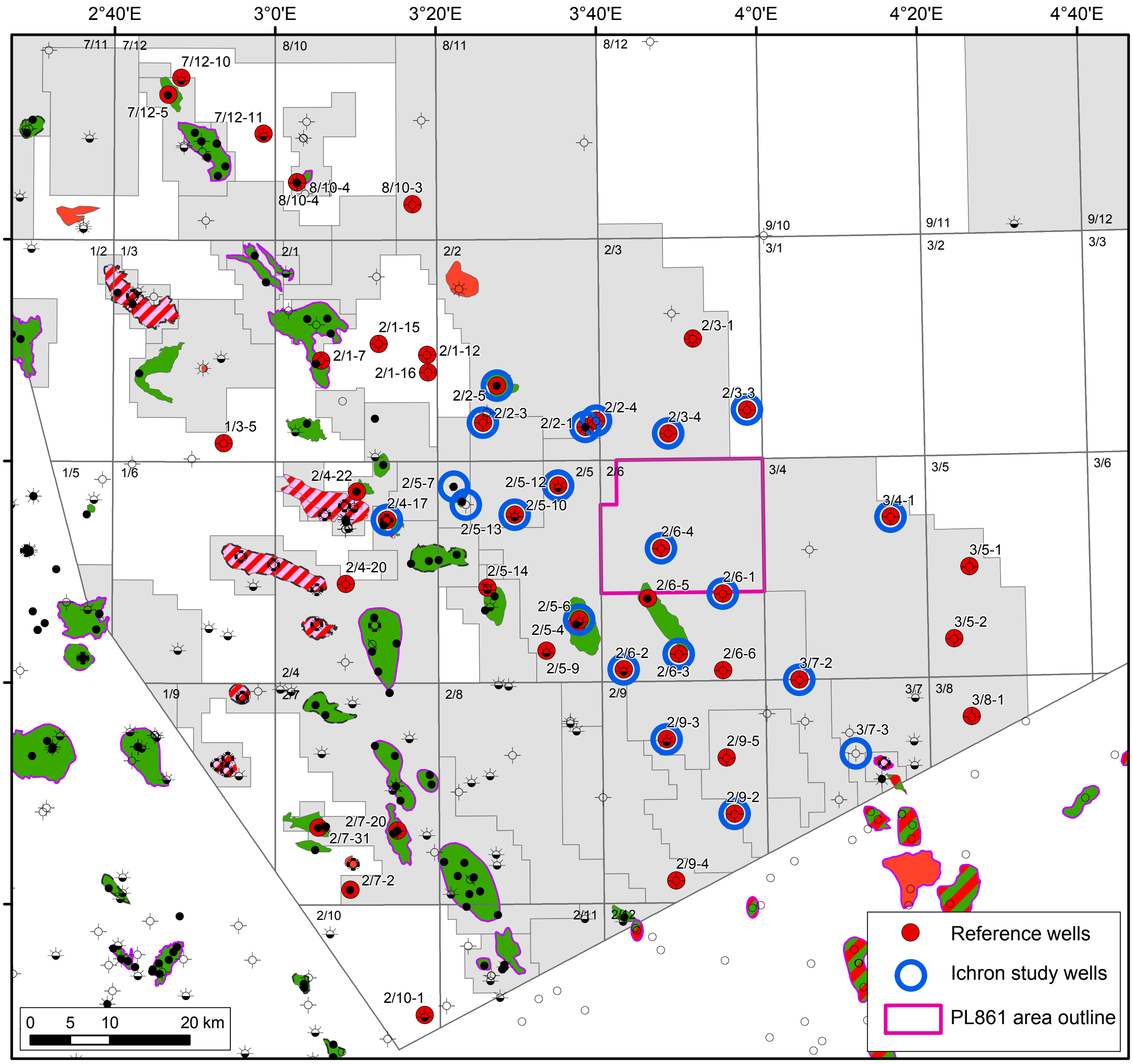

Fig. 2.2 Well database map

3 Summary of geological and geophysical studies

A number of geological and geophysical studies have been performed:

- In order to improve the data quality in the pre-Jurassic level, PGS performed a full re-processing project to optimize data quality with removal of seabed multiples
- RPS Ichron performed detailed sedimentology, biostratigraphy and petrography study on selected wells (Fig. 2.2)
- Reservoir characterization and a full inversion study was performed by Qeye Labs ApS on Jurassic level to de-risk Jurassic prospects
- In-house AkerBP rock physics, AVO and inversion study was performed to derisk the Paleocene prospectivity
- Internal petroleum system modelling studies to increase understating of migration and key uncertainties
- Internal sedimentological review of the Upper Jurassic stratigraphy and facies in and around licence area
- Surface geochemistry studies (ORG and MicroPro) that analysed geochemical and micro bacterial signatures

Seismic interpretation in the licence area is primarily carried out on the CGRN2013ABPR17 seismic data. Seismic to well ties were performed for the seven wells within the reprocessed dataset and the synthetic to real seismic match is good to moderate for all the wells. Seismic horizons that were interpreted in the area, are Top Balder, Top Paleocene Reservoir, Top chalk (top Ekofisk Fm), Base Chalk (Top Åsgard Fm), BCU (Top Mandal Fm), Top Zechstein Gp (Top salt), Base Upper Jurassic, Top Rotliegend Gp (Base salt) and Base Rotliegend Gp. The BCU (Top Mandal Fm) surface has been used to define the Top of the reservoir interval for Freki prospect. Beneath the BCU, the seismic is of moderate quality with seismic multiples making the internal Upper Jurassic interpretation difficult.The Base Upper Jurassic interpretation has been used both in basin modelling and to define the base of the reservoir interval for the Freki structure. The interpretation was done in the time domain and then depth converted using a combination of seismic and well velocities model.

Extensive geophysical work has been carried out on the reprocessed 3D survey CGRN2013ABPR17, in order to tackle the seismic challenges (mainly multiples). This includes radon transformation for multiple and noise attenuation, offset to angle conversion, rock-physics based and AVO dependent spectral shaping and warp (angle-stack alignment) to optimise the seismic data and ready to be used in inversions and lithology classification. Five wells were used for the wavelet estimation. For Low frequency model building, a lithology-driven model was chosen. A 3D simultaneous AVO inversion model was constructed for parameter optimization and wavelet testing. A lithology classification is performed on the absolute inversions. Two sets of probability density functions were created; one for the well-driven inversion results and one for the lithology-driven inversion results. Results from these studies have supported some reservoir presence over the Freki closure but extend of sand and reservoir quality remains uncertain.

Sedimentological, biostratigraphy and petrography studies in conjunction with seismic surface structural maps were integrated to construct Gross Depositional Environment (GDE) maps which helped to display possible sand fairways and reservoir distribution. Two potentially reservoir prone depositional systems were identified, namely shallow marine shore-face and gravity flows deposits (hyperpycnites) onto the shelf system.

Petroleum system modelling was carried out as part of a regional study to characterise Upper Jurassic source rock types and understand migration. Study results have shown small fetch areas on Piggvar Terrace and Søgne Basin, the latter immature for significant oil expulsion from Mandal & Farsund formations (Fig. 3.1). Surface geochemistry study was conducted in 2017 as a potential method to reduce prospects risk. For Freki Prospect, the chemical signatures are interpreted as inconclusive and the findings unable to influence the prospect risk analysis.

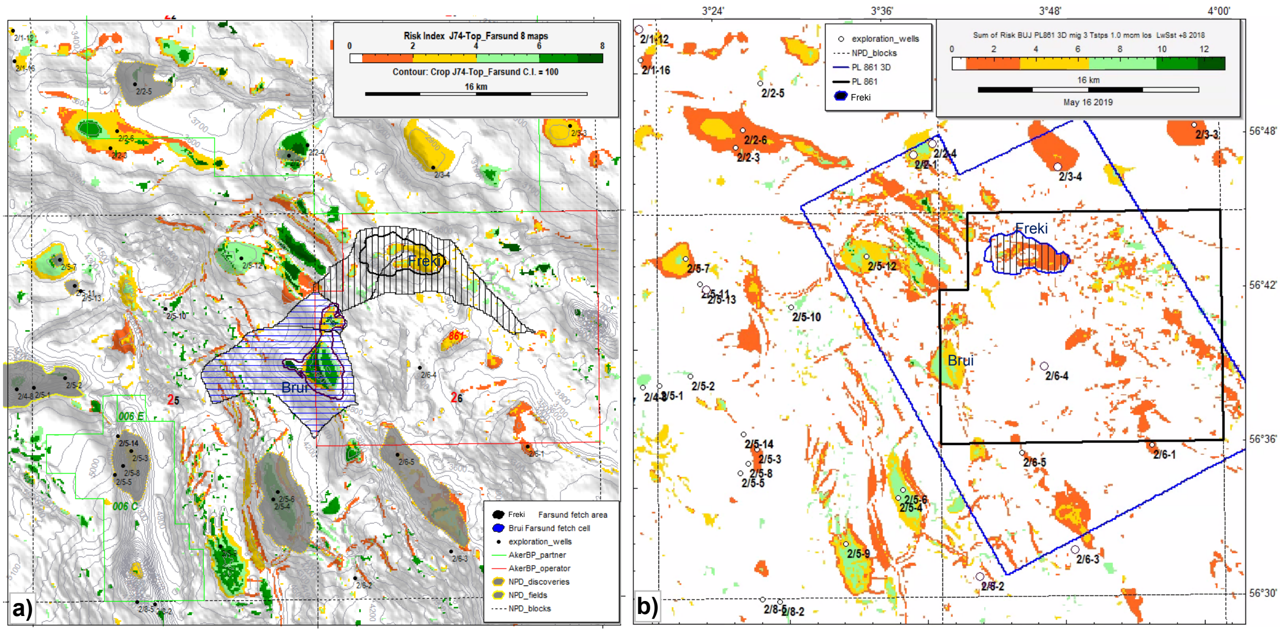

Fig. 3.1 Hydrocarbon migration risk scenarios from Upper Jurassic source rock *a) Possible fetch area outline b) Migration risk map indicating Freki is charge limited if expulsion is inefficient.*

Based on new data, studies and evaluation compared with original application award, following facts in understanding have been recognized:

- Reprocessed 3D seismic data has improved imaging and good velocity models. Otra prospect has been easily identified as a new Paleocene opportunity within the licence.
- Reservoir characterization studies have not supported any Direct Hydrocarbon Indicators (DHIs) over the Freki. The study has shown some indications of sand presence, with two possible levels of reservoir development, Upper and Lower Ula. However, the lateral extent of the sandstone and reservoir quality are uncertain.
- Petroleum system analysis has been integrated with geological model and other studies. The main risk associated with migration and some uncertainties related to in-efficient expulsion.
- The evaluation of the Ophelia prospects is a bit different than in the original application too in terms of increased reservoir and migration risk. A favourable juxtaposition of the Jurassic shale versus the Rotliegend sandstone remains the main migration risk, due to possible shale and/or salt smear along the fault plane or absent of reservoir.
- Brui evaluation has been changed from prospect to lead based on detailed G&G studies. Presence of reservoir at Upper Jurassic level is considered highly uncertain.

4 PROSPECTIVITY

At the time of application for the PL861 acreage, multiple opportunities were identified by the partnership within the Upper Jurassic (Freki and Brui) and Permian (Ophelia Main and Ophelia West) play. After integrating results of new well and interpretation of the reprocessed 3D seismic data, Otra prospect has been identified as a new Paleocene opportunity after licence award.

4.1 Freki

The main prospect, Freki, is a salt-cored 4-way dip-closure with a crestal collapse graben and radial fault pattern around the flanks of the structure (Fig. 4.1). It is expected to be sealed partly by Mandal/Farsund Formation shales and partly by shales of the Lower Cretaceous and chalk of the Hod Formation where the former is absent.

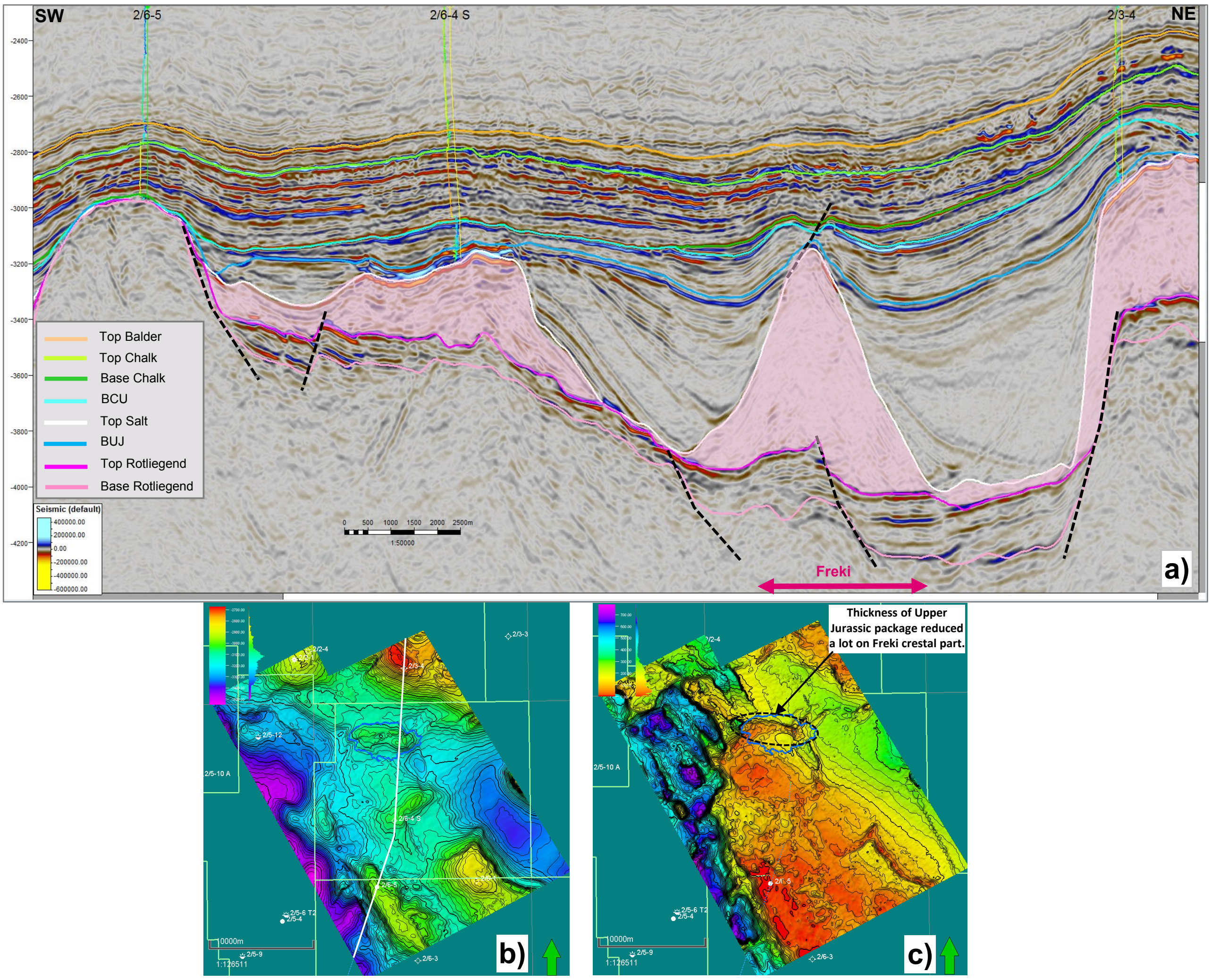

Fig. 4.1 Freki Prospect *a) Seismic line from survey CGRN2013ABPR17 showing prospsect outline b) Base Cretaceous time structure map, C.I. 20ms c) Upper Jurassic time thickness map, C.I. 30ms*

Good reservoir properties were encountered in the Jurassic sandstones in well 2/3-4, located in proximal position north of the Freki Prospect. The proposed reservoir sandstone is shaled-out to the south in well 2/6-4 S. Geological models and analogues suggests that the Freki Prospect contain Upper Jurassic shallow marine distal shore-face to gravity flow sandstones. Detailed geophysical reservoir characterization study has shown indications of sand presence, aligned with proposed depositional model; with two possible levels of reservoir development, Upper and Lower Ula. However, the lateral extent of the sandstone is uncertain. The reservoir quality is the secondary risk factor for Freki, poor permeability in the northern discovery well 2/2-1 is thought to be related to clay content.

Extensive petroleum system study has been done on a regional scale and proves the presence of a Upper Jurassic source rock in Mandal (thin), Farsund and Haugesund Formations. The study has identified small fetch areas on the Piggvar Terrace and Søgne Basin, where the latter is associated with significant risk of oil expulsion efficiency from Mandal & Farsund Fm (Ziegs et al., 2017). The prospect is thus most likely dependent on charge from the mature source kitchen in the west (Piggvar Terrace). However, migration would be highly dependent on migration across western faults, which are sealing at present day. Possible sand fairway map has showed lateral uncertainties and lack of good connection to the kitchen area. Of these reasons the charge is viewed as the main critical risk for the Freki Prospect.

The probability of discovery is estimated to 17% and the base case hydrocarbon recoverable reserves are estimated to 2.9 x 10^6 Sm^3 OE total resources. The main risk associated with the Freki Prospect is charge and the secondary risk is the quality of the reservoir.

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

Table 4.1 Risk and resource summary of the Freki Prospect.

Descriptions		**Freki (APA application)**	**Freki Ula Lower (PL861)**	**Freki Ula Upper (PL861)**
Risk factors		Risk	Risk	Risk
Reservoir	Reservoir Presence	1	0,7	0,6
	Reservoir Quality	0,8	0,5	0,5
Trap & Seal	Trap Geometry	1	1	0,5
	Seal Presence	0,7	0,8	1
Source	Source Presence	1	1	1
	Migration and timing	0,5	0,5	0,3
Retention	Retention	1	1	1
POS		*0,28*	***0,14***	***0,05***
POS (combined Freki Ula Lower & Upper)		*0,28*	***0,17***	
***Mean Rec. total resources** (10⁶ Sm³ OE)*		*18,6*	***2,9***	

4.2 Ophelia West and Main

The Ophelia West and Ophelia Main prospects are situated on a large Permian fault block located north of the northern end of the Mandal High. The two Ophelia prospects have been defined by mapping at Top Rotliegend level as shown in Fig. 4.2. Ophelia Main is a well-defined tilted normal fault block. Ophelia West is part of the less well-defined terrace area between a graben bounding fault and Ophelia Main. Top seal is provided by overlying Zechstein evaporites and lateral seal by Upper Jurassic shales and, in the case of Ophelia West, basement rocks.

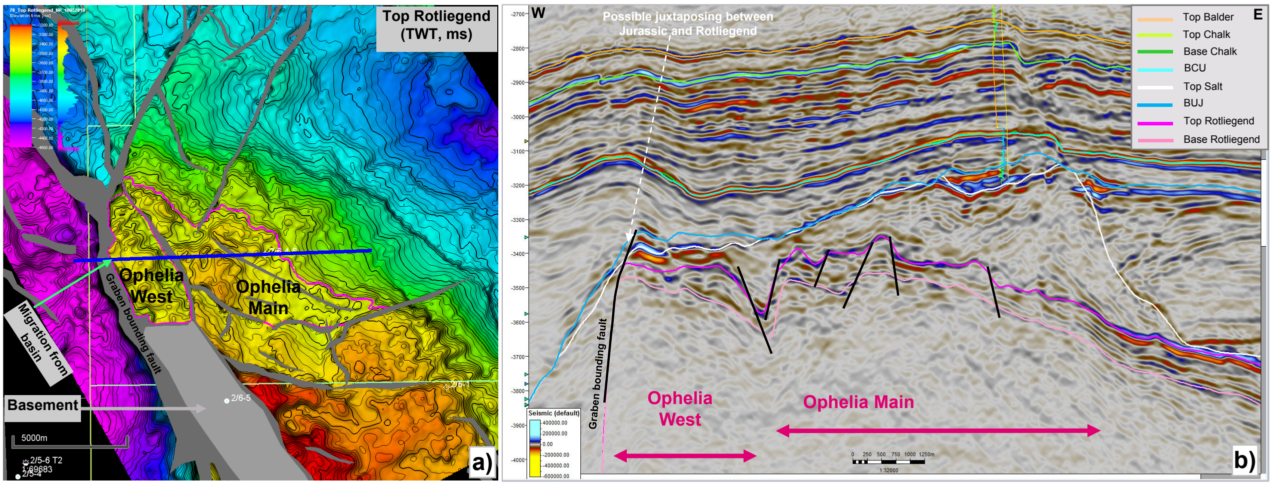

Fig. 4.2 Ophelia West and Ophelia Main Prospect *a) Top Rotliegend time structure map showing prospects outline with fault polygons b) seismic section illustrating the trapping geometry.*

Both prospects are predicted to contain eolian sandstone reservoirs of the Rotliegend Group, which is a very good reservoir rock where it has been encountered in wells 3/5-1, 2/4-17 and 8/10-3. However, some wells in close proximity to prospects have only penetrated shale and reworked volcanics in Permian level and risk for reservoir presence remains high.

The conclusion from the basin modelling study has indicated that it is likely that the Ophelia West could have received some charge from the Upper Jurassic shales. There are uncertainties related to in-efficient expulsion (Ziegs et al.,2017) and a favourable juxtaposition of the Jurassic shale versus the Rotliegend sandstone remains the biggest migration risk, due to possible shale and/or salt smear along the fault plane, or erosion of Permian reservoir on parts of the basement high. The most likely migration route into the Ophelia Main Prospect is through spill from Ophelia West. Ophelia West fetch area is charge limited and may provide petroleum to fill Ophelia West, but not Ophelia Main. Hydrocarbon charge and reservoir presence is considered the main risk of this prospect.

Table 4.2 shows the risk summary and resource distribution for the Ophelia West and Main prospects at the time of application award compared to final evaluation.

Table 4.2 Risk and resource summary of Ophelia Main and Ophelia West.

Descriptions		**Ophelia Main *(APA application)***	**Ophelia Main *(PL861)***	**Ophelia West *(APA application)***	**Ophelia West *(PL861)***
Risk factors		Risk	Risk	Risk	Risk
Reservoir	Reservoir Presence	0,7	0,4	0,6	0,4
	Reservoir Quality	1	0,8	1	0,8
Trap & Seal	Trap Geometry	1	1	1	1
	Seal Presence	0,7	0,8	0,7	0,7
Source	Source Presence	0,9	1	0,9	1
	Migration and timing	0,35	0,3	0,45	0,4
Retention	Retention	1	1	1	1
POS		*0,15*	***0,08***	*0,17*	***0,09***
Mean Rec. total resources ***(10^6 Sm^3 OE)***		*13,04*	***10,52***	*7,54*	***4,88***

4.3 Otra

Otra is a Paleocene play prospect, where gravity flow Borr sandstones is the proposed reservoir. Borr sandstones is time equivalent to the Våle and Maureen formations, and appears in the lowermost part of the Rogaland Group directly above chalks of the Shetland Group. The Otra Prospect is a combined structural and stratigraphic trap, formed by updip pinchout towards northwest and southeast which is thought to be charged from Upper Jurassic shales. The Prospect is defined by distinct soft seismic reflector above top chalk (hard event). Fig. 4.3 shows soft response and amplitude anomalies appearing on the Otra and indicates southwest-trending channelised lobe part of a system. The soft event correlates to sand in wells to the southeast. The recent well 2/6-6 S encountered an approximately 34-metre thick sandstone layer in the Intra Våle formation with good reservoir quality and it is defined by soft seismic response above top Ekofisk. In nearby well 2/5-14S on SE Tor the unit ties to a thin Borr sandstone (with oil shows) but here thickness of sands is below seismic resolution. The top reservoir horizon is delineated in the trough event, which has been correlated to the top of the Heimdal/Ty in the offset well on SE Tor, located west of the prospect.

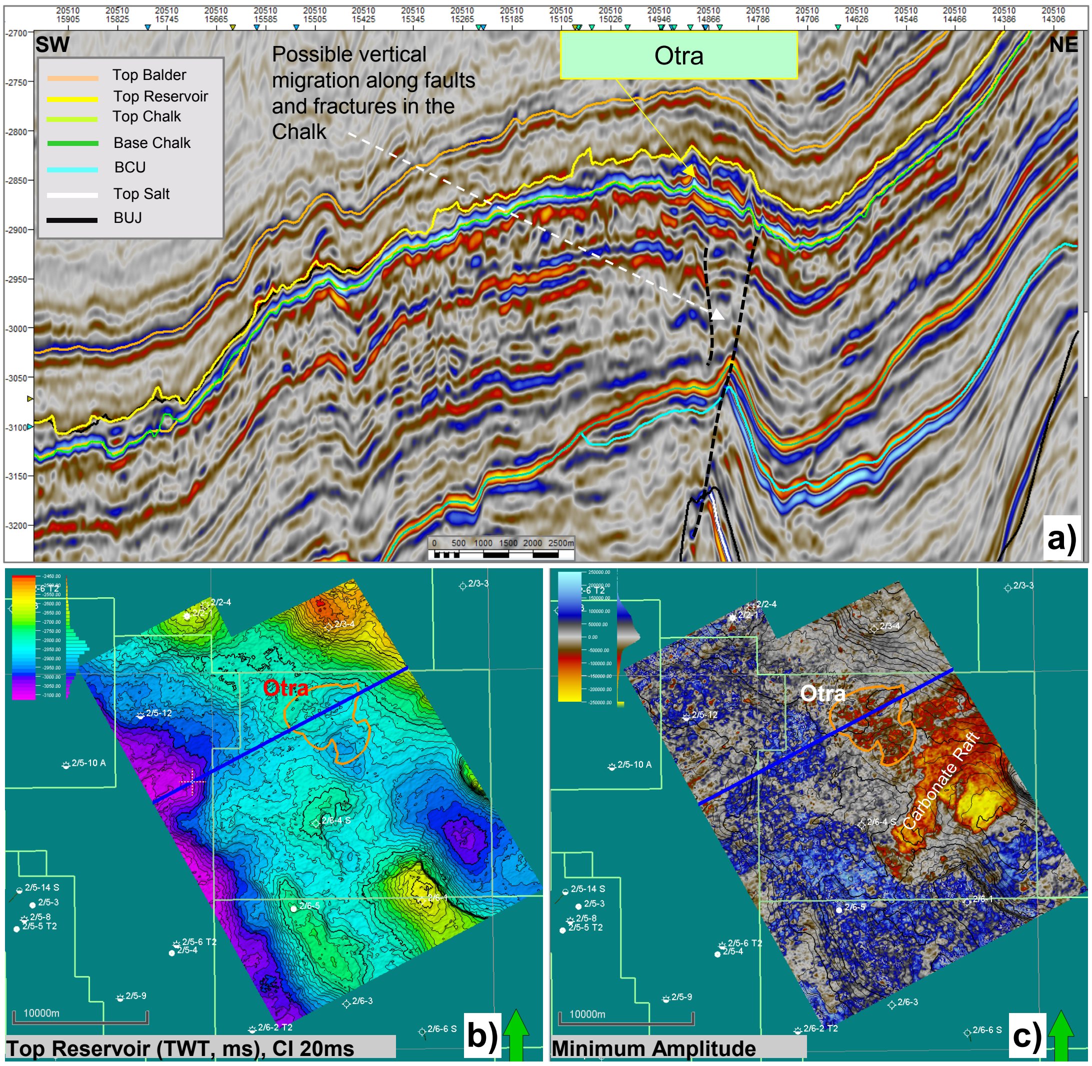

Fig. 4.3 Otra Prospect *a) Seismic section illustrating the prospect trapping geomery b) Top Reservoir time structure map showing prospect outline c) Minimum amplitudes map extracted from CGRN2013ABPR17 (stack 31-38) from Paleocene Top Reservoir*

Seismic inversion study and proposed depositional model indicate that reservoir is likely to be present (Fig. 4.4). A few chalk raft blocks are observed near the Otra sand fairway. Erosion product from these rafts can increase the chance of carbonate cementation in sandstones and degraded reservoir quality in the Otra Prospect.

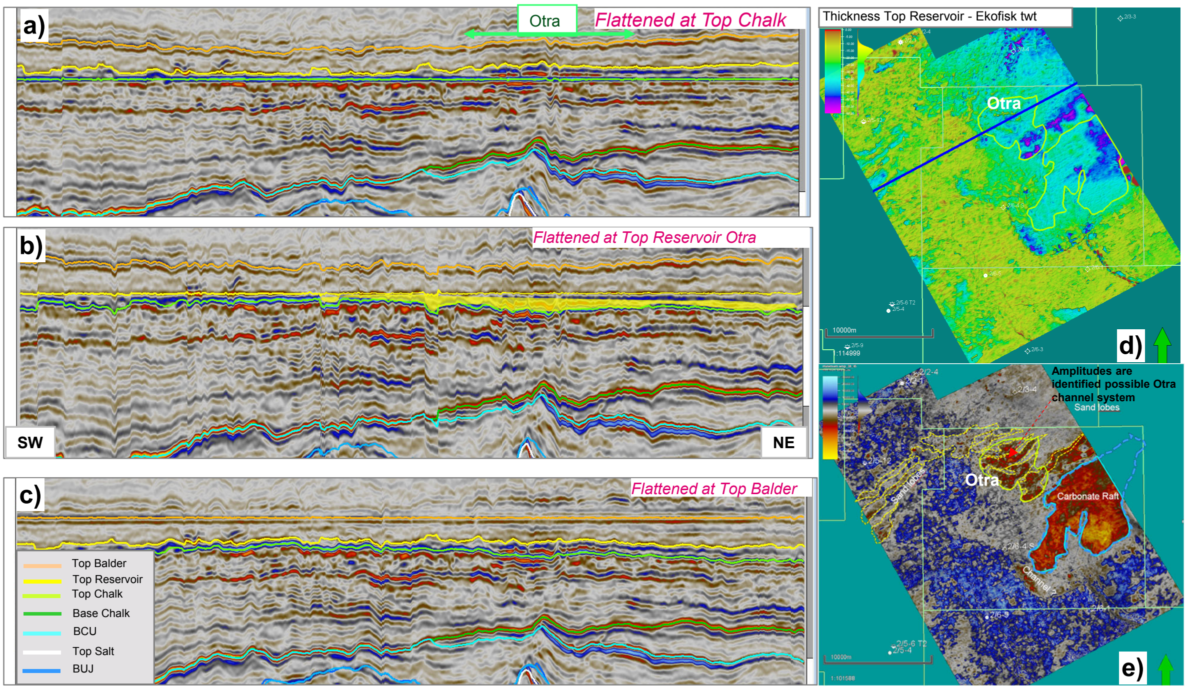

Fig. 4.4 Paleocene sandfairway model *Otra Prospect interpreted seismic section a) section flattened at Top Chalk b) Flattened at Top Reservoir c) Flattened at Balder d) Paleocene reservoir thickness map twt e) Paleocene sandfairway outline (yellow dots)*

Migration of hydrocarbons is the main risk for the Otra Prospect because it is highly dependent on complex migration path through the Freki Prospect and Cretaceous fault seal. Vertical migration along faults (Fig. 4.3) and fractures in the Chalk near PL861 is seen in well 2/6-5 and 2/6-4 S but there are some uncertainties related to in-efficient expulsion (Ziegs et al.,2017).

Secondary risk is seal. The challenge is in lateral seal towards NE, possible presence of thin thief sandstone or reworked chalk layer. Prospect base seal is partly depending on the chalk with questionable sealing capacity.

The probability of discovery is estimated to 17% and the mean case hydrocarbon recoverable reserves are estimated at 4.98 x 10^6 Sm^3 OE total resources. Table 4.3 is showing the individual risk factors for the Otra prospect.

Table 4.3 Risk summary Otra prospect

Descriptions		Risk
Reservoir	Reservoir Presence	0,9
	Reservoir Quality	0,6
Trap & Seal	Trap Geometry	0,9
	Seal Presence	0,7
Source	Source Presence	1
	Migration and timing	0,5
Retention	Retention	1
POS		***0,17***

4.4 Brui Lead

The Brui lead is located in the southwestern part of PL861. It was formed by post-rift inversion and exhibits a four-way dip-closed trapping geometry on the BCU map (Fig. 4.5). The mapped closure is straddling the licence boundary and approximately 10% is off-block. The structure can contain Upper Jurassic gravity flow reservoir sandstones similar to what has been encountered in offset wells like 2/2-1 and 2/2-4. Reservoir sandstones are believed to be sourced from the footwall of the Coffee Soil Fault to the north and potentially transported along relays and faults margins into the Brui area. However, some wells in close proximity to Brui have only penetrated shale in the Upper Jurassic section and risk for reservoir presence remains very high. The trap is expected to be sealed by Upper Jurassic shales and Upper Cretaceous chalk.

Multiple attempts (reprocessed seismic data and detailed geophysical evaluation) has been done to map possbile reservoir and sand fairways. Presence of reservoir at Upper Jurassic level is deemed highly unlikely (Fig. 4.5). As a consequence, resource assessment and risk evaluation has not been carried out for Brui.

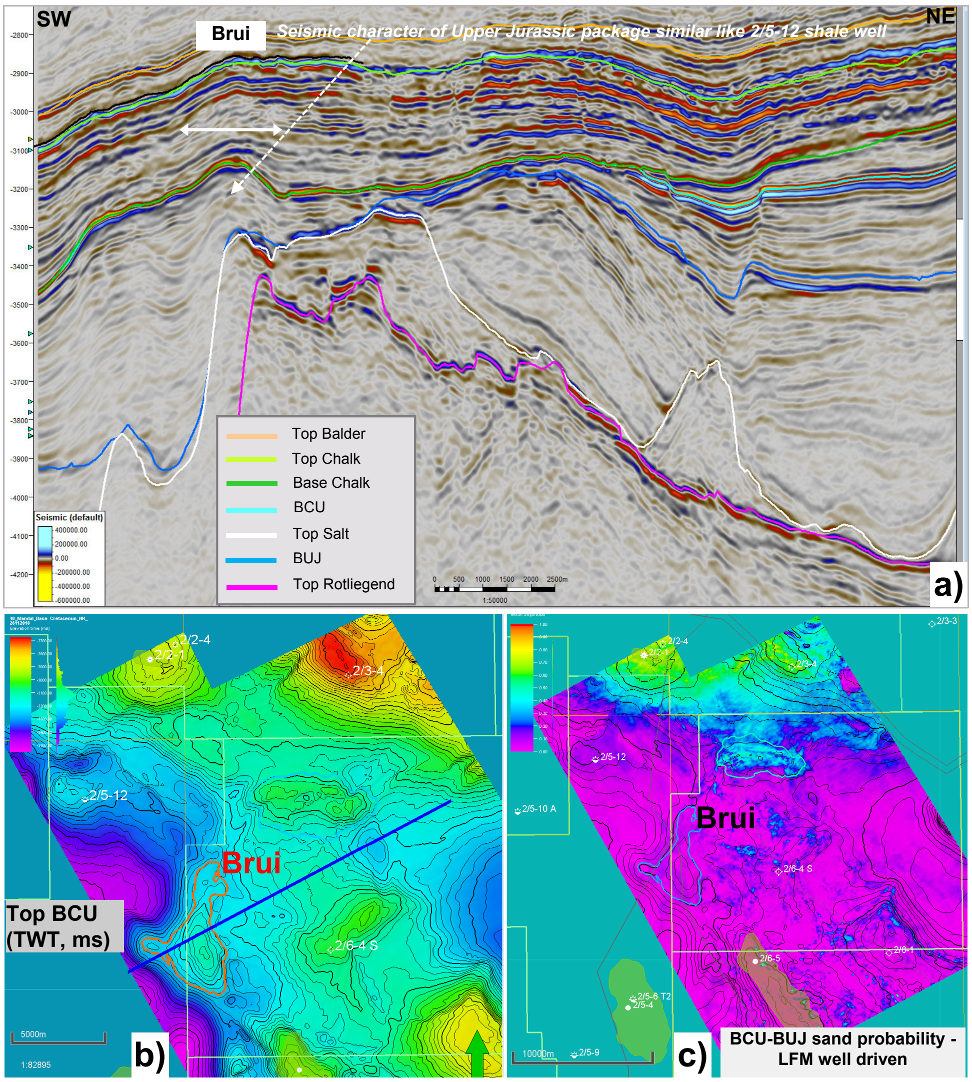

Fig. 4.5 Brui Lead *a) Seismic section from survey CGRN2013ABPR17 showing prospect outline b) BCU time structure map illustrating the trapping geomery c) Upper Jurassic sand probability map from inversion study. The map shows lack of sand probability within the Brui outline.*

4.5 Technical Evaluation

The resource potential of the identified prospects are too low to be of economic interest as tie-in candidates to existing infrastructure in the area (e.g. Valhall) or as a stand-alone candidates. Therefore, technical evaluation has not been carried out for the prospect.

5 CONCLUSION

Geological studies carried out to put the licence area into regional geologic context as part of the work program has improved the understanding of PL861. Detailed seismic interpretation, geophysical evaluation, reservoir study and petroleum system modelling study have highlighted the significant challenges to de-risk the charge of the main Freki Prospect on the licence. Reservoir has also been identified as a secondary risk.

The overall resource potential and associated risks for the different prospects identified in PL861 are presented in Table 5.1. The prospectivity shows relatively low resource potential and high risk picture. Non of the prospects were viewed as drilling candidates and the licensees have thus concluded to relinquish the lisence.

Table 5.1 Remaining resource potential in PL861

Prospect name	P (prospect)/ L (lead)	Litho-/ Chronostratigraphic	Phase	Main Risks	POS (%)	Resources mean Ass. gas Rec. (M Sm^3 OE)	Resources mean Oil Rec. (M Sm^3 OE)
Freki	P	Ula Fm / Upper Jurassic	Oil	Charge and Reservoir	0.17	0.197	2.72
Ophelia Main	P	Rotliegend Gp / Permian	Oil	Charge and Reservoir	0.08	0.711	9.81
Ophelia West	P	Rotliegend Gp / Permian	Oil	Charge and Reservoir	0.09	0.329	4.55
Otra	P	Våle Fm(Borr sst.) / Paleocene	Oil	Charge and Seal	0.17	0.365	4.61
Brui	L	Ula Fm / Upper Jurassic	Oil	Reservoir absent			

6 REFERENCES

Ziegs, V., Horsfield, B., Skeie, J.E. and Rinna, J. (2017) Petroleum retention in the Mandal Formation, Central Graben, Norway. Marine and Petroleum Geology 83, 195-214.