License Surrendering Report, PL797

LOTOS Exploration & Production Norge

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1. Key license history

The PL797 license was awarded in APA 2014. It was granted in February 2015 with LOTOS E&P Norge AS as operator. The other partners were Svenska Petroleum Exploration AS, Spike Exploration Holding AS and Petoro AS (listed in Table 1).

Table 1 PL797 partners and interest

Company longname Feb 2015	Interest	Company longname Feb 2017
LOTOS Exploration and Production AS	30 % (OP)	LOTOS Exploration and Production Norge AS
Svenska Petroleum Exploration AS	25 %	Aker BP ASA
Spike Exploration Holding AS	25 %	Piont Resources AS
Petoro AS	20 %	Petoro AS

Work program

In accordance with the work obligations (Table 2) and to better understand the prospectivity the license has acquired and reprocessed 3D seismic data shot in 2014 by PGS. The reprocessing was done by Geokinetics Processing UK Ltd. It was completed in June 2016, giving the license 6 months to evaluate the prospects based on the new seismic. The technical work included geological, petrophysical, geophysical, basin modelling and geochemistry studies prior to the drill or drop decision 6th of February 2017.

Table 2 Work obligation PL797 (from NPD website)

⊟ Work obligations

Work obligation	Decision	Task status	Expiry date	Wellbore if drilled
Reprocessing of 3D seismic		Approved		
	Consider acquisition of existing 3D seismic		06.02.2016	
Acquire 3D seismic		Approved		
	Decision to drill	Not to be drilled	06.02.2017	
Drill exploration well		Not to be drilled		
	Decision to concretize (BoK)	In process	06.02.2019	
Conceptual studies		In process		
	Decision to continue (BoV)	In process	06.02.2021	
Prepare plan for development (PDO)		In process		
Submit plan for development		In process		
	The expiry of initial period	In process	06.02.2022	
Relinquishment report		In process		

No applications for extension of deadline have been submitted. Overview of meetings held in the license is given in Table 3.

Table 3 Overview of meetings held in PL797

Date	Type	Agenda
2015.09.02	Internal	Kick off meeting
2015.04.09	EC/MC	License establishment, prospect review, database, reprocessing, work program and budget.
2015.10.29	WM	Depth conversion, geochemistry and basin modelling
2015.06.24	EC/MC	Pressure, reprocessing, DC, database, G&G studies, budget, plan, risk
2015.11.18	EC/MC	Reprocessing, geochemistry & basin modelling, G&G, budget, project plan, risk and way forward.
2016.05.26	WM	Reprocessing, fluid substitution & AVO, geochemistry
2016.06.21	EC/MC	Reprocessing, G&G, budget, project plan, license risk, field trip, way forward.
2016.11.03	WM	Seismic Interpretation, Depth Conversion, AVO & Inversion, Pressure study, Geochemistry, Basin Modelling, Reservoir parameters & Volume calculations.
2016.12.06	EC/MC	G&G studies, HC volume and risk, Technical & Economic Evaluation, Work programme, Budget, Project plan, License risk, Way forward.

Reason for surrendering

Based on the results from the G&G studies the recommendation from the operator, was to apply for a two (2) years extension to do PSDM processing of the seismic data in order to; evaluate the sealing potential of crucial faults, improve the definition off the Jaana prospect, apply for a license extension towards the north to include the northern part of the Jaana prospect, update the basin modelling and the G&G work prior to a final drill or drop decision. Petoro supported this view. However:

- Point Resources AS did not support the operator
    - As a result of the depth conversion, part of the license work program (First Geo study), the main prospect Ina needed to be redefined. Consequently, the resource potential and the associated geological chance of success both changed in a negative direction with reference to Point Recourses own evaluation. Furthermore, Point did evaluate if the proposed work program suggested for the license extension period would significantly de-risk the new prospect definition and came up with a negative conclusion.
- Aker BP did not support the operator because they considered the trap risk too high.

2. Database

Seismic database

The licence area is covered by multiple seismic surveys of varying vintage and quality. The APA 2014 application mapping was based on the 2011 Mid-Norway TerraCube 3D seismic volume from Fugro. The license acquired part of the PGS1401 seismic survey and reprocessed it (PGS14RLO1601-PSTM). The resulting data was considered to be of good quality and was used as the basis for the seismic interpretation, the AVO study and as input to the depth conversion.

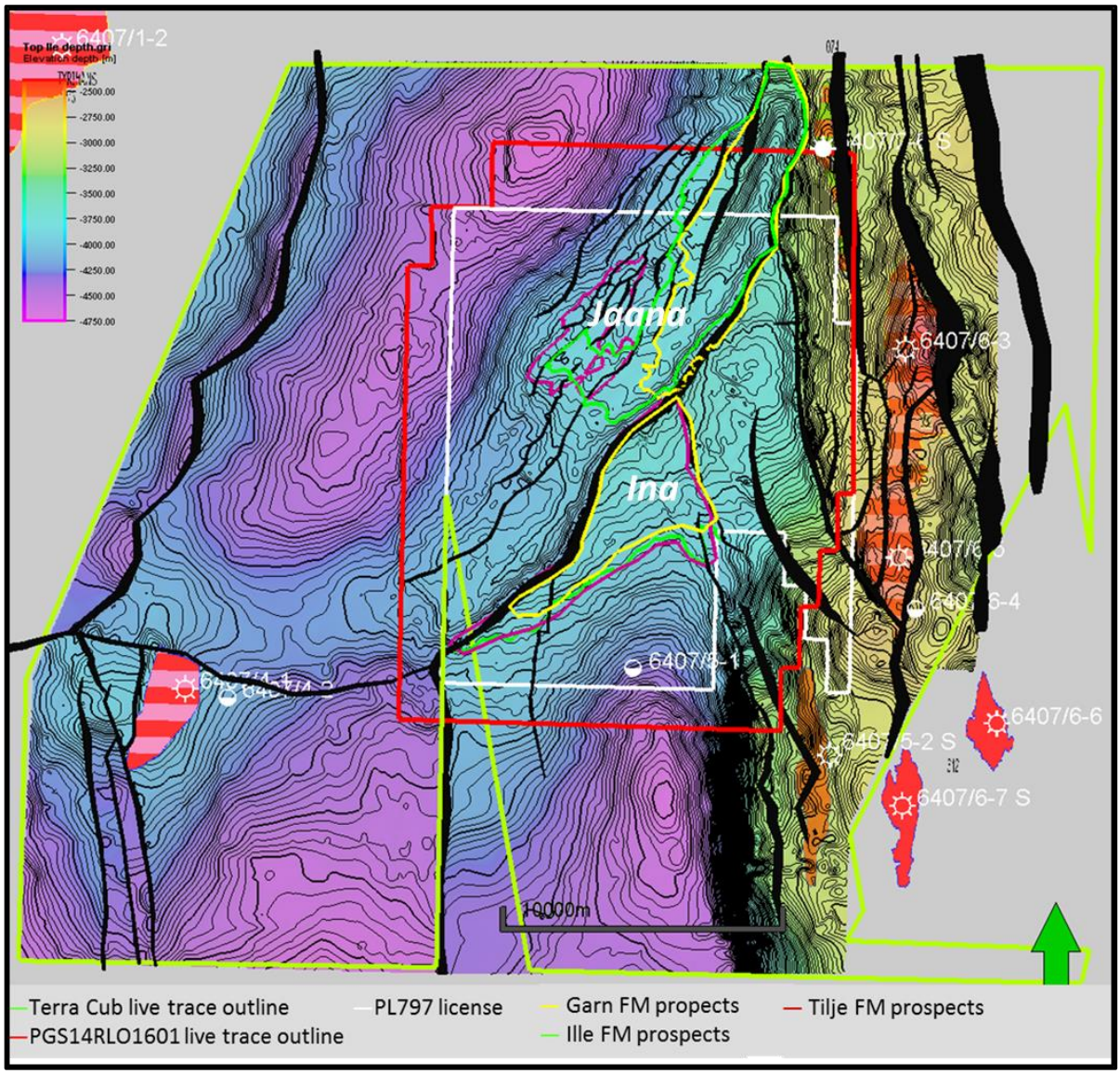

Figure 1 Top Ile Fm depth map.
Showing the Ina and Jaana outlines, the seismic coverage of the PGS14RLO1601, nearby wells and fields & discoveries.

Well database

All relevant wells were evaluated for the prospectivity analysis. Table 4 shows the common well database.

Table 4 Common welldatabase

Well	Year	Fm. at TD	Data	Correlation well	Comments
6406/6-1	1985	Tilje	Logs,CPI,WellTops		
6406/6-2	2007	Tilje	Logs,CPI,WellTops		
6406/9-1	2005	Åre	Logs,CPI,WellTops		Linnorm discovery
6407/1-2	1983	Late Triassic	Logs,CPI,WellTops		Tyrihans field
6407/2-1	1982	Late Triassic	Logs,CPI,WellTops	yes	
6407/2-3	1987	Åre	Logs,CPI,WellTops	yes	Midgård field
6407/2-5S	2009	Åre	Logs,CPI,WellTops		
6407/2-6S	2010	Åre	Logs,CPI,WellTops	yes	
6407/3-1S	2012	Tilje	Logs,CPI,WellTops		
6407/4-1	1985	Åre	Logs,CPI,WellTops,Core,Samples,Thin Sections,Comp&DiscoveryReports	yes	SpinellDiscovery,most relevant well,seismic-to-well tie
6407/4-2	2011	Ile	Logs,CPI,WellTops,Core & reports		Spinell appraisal
6407/5-1	1988	Garn	Logs,CPI,WellTops		
6407/5-2S	2011	Early Jurassic	Logs,CPI,WellTops	yes	
6407/6-1	1984	Late Triassic	Logs,CPI,WellTops		
6407/6-3	1987	Åre	Logs,CPI,WellTops	yes	Mikkel discovery
6407/6-4	1990	Åre	Logs,CPI,WellTops		Mikkel field
6407/6-6	2008	Tilje	Logs,CPI,WellTops		Mikkel Sør field
6407/6-7S	2009	Åre	Logs,CPI,WellTops		
6407/7-1S	1986	LateTriassic	Logs,CPI,WellTops		Njord field
6407/7-5	1991	Åre	Logs,CPI,WellTops		Njord field
6407/7-8	2008	Åre	Logs,CPI,WellTops	yes	Noatun discovery
6407/8-4S	2008	Åre	Logs,CPI,WellTops		
6407/8-5S	2009	Triassic Grey Beds	Logs,CPI,WellTops		Hyme discovery
6406/6-3	2013	Åre	Logs,CPI,WellTops		Mjøsa
6407/8-6	2013	Grey Beds	Logs,CPI,WellTops		Snilehorn

Studies database

In conjunction with the prospectivity evaluation of PL797, the license has acquired and performed the following studies:

- Hydrocarbon Prospectivity Mid Norway, by First Geo
- HiQbe with velocity input from the reprocessing done by First Geo (proprietary)
- Basin modelling to evaluate the hydrocarbon migration in the area and to investigate the impact of sealing faults on the migration and trapping. Performed by Migris (proprietary)
- Geochemistry, oil to source correlation done by Exploro (proprietary)
- Petrophysical analyses by First Geo
- Depth conversion by First Geo
- Fluid substitution, seismic AVO and angel-dependent inversion study
- Pressure study

3. Review of Geological and Geophysical studies

In the APA application the Ina and Jaana prospects were identified by the AMI group. All of the prospects where based on a Lower and Middle Jurassic play concept with potential stacked reservoirs in the Garn-, Ile- and Tilje Formations. The technical work after the award focused on maturing either Ina or Jaana as drillable prospects. The main risk identified for the Ina prospect in 2014 was related to sealing faults, trap definition, timing and migration. Several studies were initiated to address these risks.

Acquiring and reprocessing of the PGS1401 3D seismic data improved the trap definition of both the Ina and Jaana prospects. With the new interpretation and depth conversion the trapping mechanisms in both Ina and Jaana has changed. Ina is pending on sealing capacities of a fault with a throw of ~100m (Figure 2). Jaana have a 4 way closure on Tilje Fm level inside the license, whilst both Ile Fm and Tilje Fm have closure outside the licensed area to the North (Figure 1 and Figure 3).

The interpretation incorporated new geological understanding that helped defining the framework of source rocks, fetch areas and fault block that contain reservoirs. A full 3D basin modelling study, incorporating pressure analysis and fault sealing, was performed. It concluded that the area have generated enough hydrocarbons to fill the prospects, and that gas condensate is the most likely phase of the prospects at Garn- and Ile Fm, while gas was most likely for Tilje Fm.

The reprocessed seismic data was analyzed by a seismic inversion workflow investigating any fluid or lithology effects in the seismic. The initial fluid substitution study performed on the wells showed that a small change in seismic response might be visible at this depth; however no HC indications consistent with depth was observed in the inversion results.

The lack of good well information from the reservoir formations inside the coverage of the reprocessed seismic data reduces the quality for geophysical evaluation tools such as amplitude vs offset (AVO) and angel-dependent inversion (ADI) evaluations.

An analysis of hydrocarbon column heights and pressure in the area concluded that many structures were under-filled or may have leaked, and that the prospects most likely are in or close to hydrostatic pressure regime and hence not high pressure (>150bar). Since top seal capacity is robust based on LOT's, top seal is not considered a risk.

Reservoir presence and quality has been addressed with a semiregional reservoir quality study of wells based on cored intervals combined with a sedimentological and petrophysical analysis. The porosity vs. depth trend shows fairly constant porosity values with increasing depth indicating preservation of reservoir quality at prospects burial depth. Some of the sections in the Lower Jurassic to Middle Jurassic sandstones show exceptionally good porosity preservation at depth. This is probably associated with chlorite coating.

In the APA 2014 application the depth conversion was an element of significant uncertainty. With the support of First Geo the license have corrected check shot inconsistencies in many of the wells close to PL797 and used this with new stacking velocities from the reprocessing to update the velocity

model. An industry standard method was used for the depth conversion, with average velocity (Va) from wells and scaled stacking velocities down to BCU and interval velocity functions below. The objective is to minimize the uncertainty and to find a reliable scaling factor, so that Va becomes as accurate as possible. Uncertainty analyses carried out on the depth conversion, using multiple realizations of the 3D velocity model spanning the space of possible outcomes, showed that the changes in gross rock volume were not significant. Furthermore there were small chances of having a significant independent closure not pending on lateral seal towards the north-west. Hence the depth conversion is no longer seen as a major uncertainty.

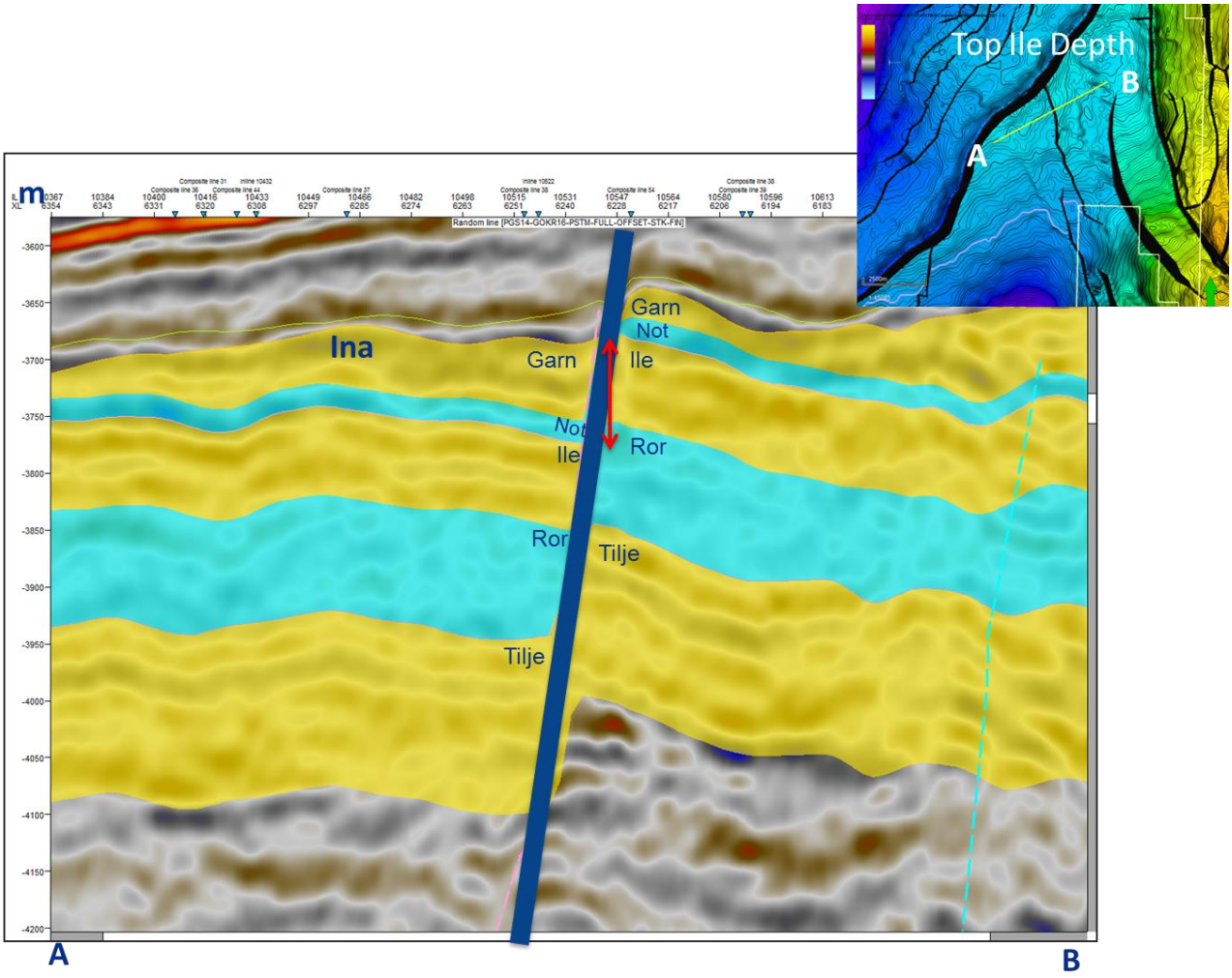

Figure 2 Seismic line in depth with the critical NW-SE fault.
Ina Prospect on the left side is dependent on the sealing capacity of the fault for hydrocarbon trapping

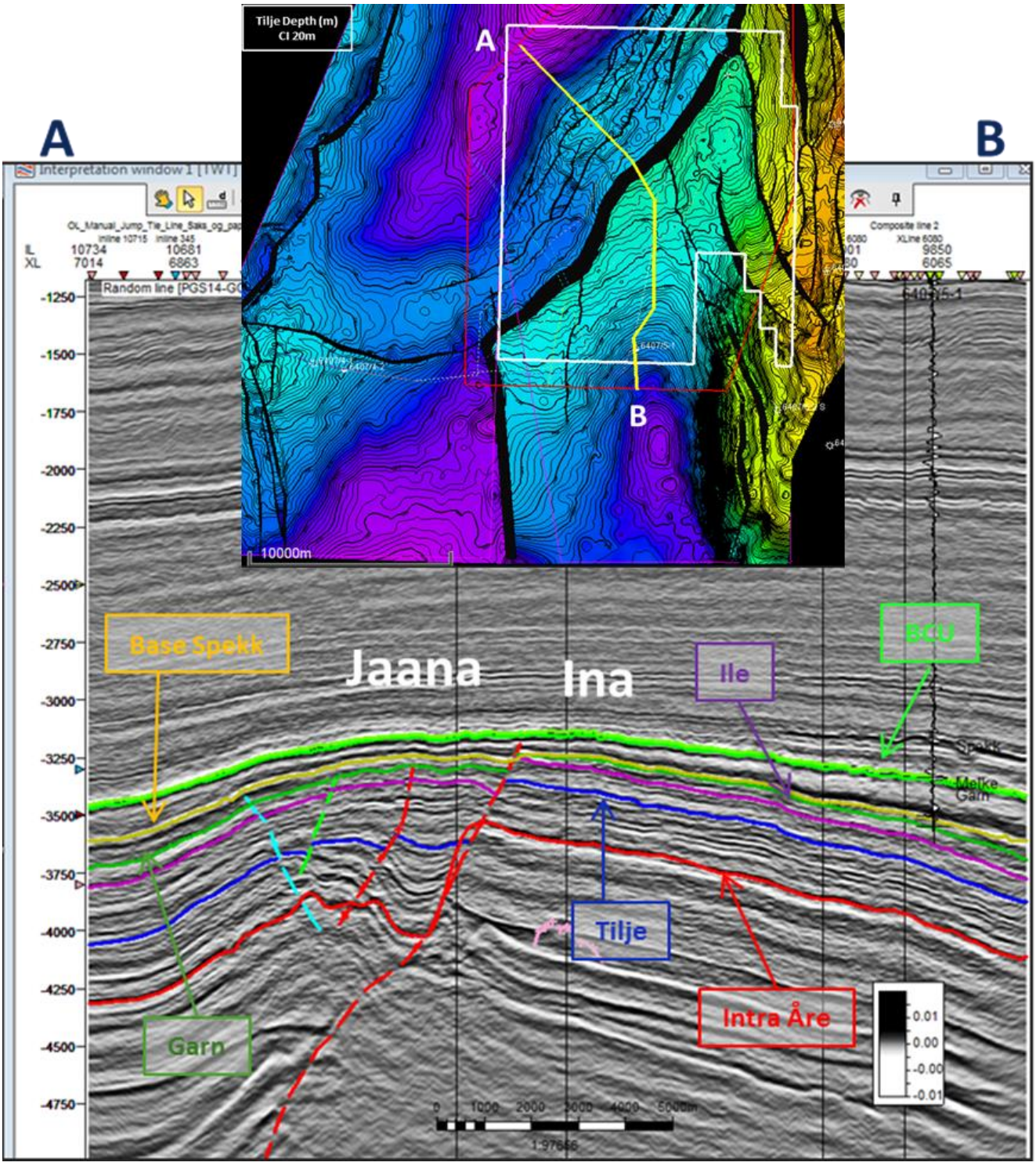

Figure 3 Top Tilje Depth map and seismic profile.
Showing the rotated fault block with the Ina prospect and the more complex rollover anticline which constitutes the Jaana Prospect

4. Prospect update report

The license work program, with new seismic and several G&G studies **Error! Reference source not found.**resulted in several changes of the view of the prospects i.e. main prospect, fluid type and volumes. A comparison of the 2017 vs 2014 mean volumes shows significant higher volumes in Ina Garn- and Ile Fm, and lower volumes in Tilje Fm compared to in 2014. Table 5 shows the operators inplace and recoverable volume calculations for the different prospects. Gas condensate is expected for Garn- and Ile Fm's while gas is expected for Tilje Fm.

Table 5 In place and recoverable volumes with chance of success (cos). Gas condensate phase for Garn- and Ile Fm, Gas for Tilje Fm

PROSPECT			Ina/Garn COS 34%	Ina/Ile COS 33%	Ina/Tilje COS 21%	Jaana/Garn COS 22%	Jaana/Ile COS 22%	Jaana/Tilje COS 23%
Resources (mill Sm3 o.e.)	In Place	P90	8	3.2	0.77	2.3	1.4	0.2
		P50	20.8	26.3	9.93	28.3	21.9	2.2
		P10	39.1	71.8	36.1	119.5	104.9	7
	Recoverable	P90	3.36	1.22	0.425	0.875	0.566	0.106
		P50	8.39	10.4	5.43	11.1	8.65	1.14
		P10	15.4	28.3	20.1	48.5	43.1	3.64

Table 6 Primary prospect Ina risk table

Prospect/ Risk	Overall COS/COS	Comment
Ina/Garn	34 %	Primary Target
Reservoir	80 %	Reservoir proven in surrounding wells. Data at this burial depth show sufficient Por/Perm to produce oil and gas. Possible presence of chlorite coating.
Trap	60 %	Main risk. Prospect dependent on sealing fault to the NE. SGR modelling show good chance of sealing fault. Shale - SST juxtaposition (Ile). No AVO.
Charge	90 %	Ina surrounded by Oil/Gas discoveries. Basin modelling show that available charge fills the prospects to spill.
Retention	80 %	Competent top seal (Spekk, Melke, Ror, Not), observed in nearby wells. Pressure study show that the max hydrocarbon columns do not breach the seal. However, some faults penetrate the top seal.

Prospect/ Risk	Overall COS/COS	Comment
Ina/Ile	33 %	Primary Target, dependency on Ina Garn.
Reservoir	80 %	Reservoir proven in surrounding wells. Data at this burial depth show sufficient Por/Perm to produce oil and gas. Possible presence of chlorite coating.
Trap	65 %	Main risk. Prospect dependent on sealing fault to the NE. SGR modelling show good chance of sealing fault. Shale – SST juxtaposition (Not). No AVO.
Charge	80 %	Ina surrounded by Oil/Gas discoveries. Basin modelling show that available charge fills the prospects to spill.
Retention	80 %	Competent top seal (Spekk, Melke, Ror, Not), observed in nearby wells. Pressure study show that the max hydrocarbon columns do not breach the seal. However, some faults penetrate the top seal.

Prospect/ Risk	Overall COS/COS	Comment
Ina/Tilje	21 %	Secondary Target.
Reservoir	80 %	Reservoir proven in surrounding wells. Data at this burial depth show sufficient Por/Perm to produce oil and gas. Possible presence of chlorite coating.
Trap	65 %	Main risk. Prospect dependent on sealing fault to the NE. SGR modelling show good chance of sealing fault. SST – SST juxtaposition (Tilje) No AVO. Higher SGR.
Charge	50 %	Ina surrounded by Oil/Gas discoveries. Basin modelling shows that charge to Tilje may be a problem to fill to spill.
Retention	80 %	Competent top seal (Spekk, Melke, Ror, Not), observed in nearby wells. Pressure study shows that the max hydrocarbon columns do not breach the seal . However, some faults penetrate the top seal.

Table 7 Secondary prospect Jaana risk table

Prospect/ Risk	Overall COS/COS	Comment
Jaana/Garn	**22 %**	Primary Target
Reservoir	80 %	Reservoir proven in surrounding wells. Data at this burial depth show sufficient Por/Perm to produce oil and gas. Possible presence of chlorite coating. Deeper burial then Ina.
Trap	40 %	Seismic data affected by strong amplitudes in the overburden and multiples. Complex heavily faulted salt affected roll over anticline. Seismic definition of the trap is a challenge and lack of seismic data in the NE to close the prospect. No AVO. Fault seal dependence to the NE.
Charge	75%	Jaana surrounded by Oil/Gas discoveries. Charge from Gimsan North basin. Basin modelling shows that the traps may be under filled due to insufficient charge.
Retention	90 %	Competent top seal (Spekk, Melke, Ror, Not), observed in nearby wells. Pressure study shows that the max hydrocarbon columns do not breach the seal. However, some faults penetrate the top seal.

Prospect/ Risk	Overall COS/COS	Comment
Jaana/Ile	**20 %**	Primary Target, dependency on Jaana Garn.
Reservoir	80 %	Reservoir proven in surrounding wells. Data at this burial depth show sufficient Por/Perm to produce oil and gas. Possible presence of chlorite coating. Deeper burial then Ina.
Trap	40 %	Seismic data affected by strong amplitudes in the overburden and multiples. Complex heavily faulted salt affected roll over anticline. Seismic definition of the trap is a challenge and lack of seismic data in the NE to close the prospect. No AVO. Fault seal dependence to the NE.
Charge	70 %	Jaana surrounded by Oil/Gas discoveries. Charge from Gimsan North basin. Basin modelling shows that the traps may be under filled due to insufficient charge.
Retention	90 %	Competent top seal (Spekk, Melke, Ror, Not), observed in nearby wells. Pressure study show that the max hydrocarbon columns do not breach the seal. However, some faults penetrate the top seal.

Prospect/ Risk	Overall COS/COS	Comment
Jaana/Tilje	**23 %**	Secondary Target.
Reservoir	70 %	Reservoir proven in surrounding wells. Data at this burial depth show sufficient Por/Perm to produce oil and gas. Possible presence of chlorite coating. Deeper burial then Ina.
Trap	75 %	Seismic data affected by strong amplitudes in the overburden and multiples. Complex heavily faulted salt affected roll over anticline. Seismic definition of the trap is a challenge and lack of seismic data in the NE to close the prospect. No AVO. Significant 4way closure. Maximum closure dependent on fault seal to the NE. risked four way dip closure.
Charge	50 %	Jaana surrounded by Oil/Gas discoveries. Charge from Gimsan North basin. Basin modelling shows that the traps may be under filled due to insufficient charge. For the Tilje reservoir charge is less then for Garn and Ile, typical for surrounding wells.
Retention	90 %	Competent top seal (Spekk, Melke, Ror, Not), observed in nearby wells. Pressure study show that the max hydrocarbon columns do not breach the seal . However, some faults penetrate the top seal.

5. Technical evaluations

A review was preformed to assess the technical and economic aspects of the PL797 prospects. The aim was to test the minimum economic volume (MEV) needed for having a commercial discovery. MEV is based on the smallest possible development of PL797, with scaling or reserves to find the recoverable reserves needed for having NPV>0. Probability of discovery is not taken into account, and the estimation is based on a discovery case. The following technical and commercial assumptions are made:

- One exploration well in 2020, cost of 500 mill NOK real 2016
- Development solution with subsea tie-back to Åsgard (Midgard). Distance to Åsgard (Midgard) is 35-40 km
- One production well with production start-up in 2025. 16 years of production
- Mikkel production profile used as basis for simplicity. Mikkel is a 3 well development; the profile has been divided by 3 to get single well producer. Mikkel GOR~2300 - PL797 GOR 1600; liquid production increased by 1,43. After plateau a decline rate of 12% has been applied
    - Recoverable reserves of 6,7 Bcm gas and 26 mmbbl condensate
- Recently approved development projects used as basis for cost estimates for template, pipeline, SPS and topside modifications
- Recently approved development projects used as basis for cost estimates for subsea opex and well opex
- Woodmac assumptions used as basis for processing & transportation tariffs

For the economic analyses the following is assumed:

- Discovery case (exploration costs included in economics)
- Woodmac assumptions for prices, inflation, exchange rates and nominal discount rate
    - Long term oil price 70 USD/bbl (real 2016)
    - Long term gas price 1,88 NOK/sm3 (real 2016)
    - NOK/USD 6,8
    - Long term inflation 2%
    - Nominal discount rate of 10%
- Discount date mid 2016
- Results calculated both with unconsolidated (stand-alone) and consolidated tax approach

The results given in Table 8 shows that the minimum recoverable economic volume is 4,5 mill m^3 o.e (28 mmboe).

Table 8 Results for the technical and economical evaluation

Consolidated

Consolidated tax approach		**mill NOK**	**mill $**
After-tax cashflow	10,00 %	1181,3	173,2
Oil price (USD16/bbl)	70		
Gas price (NOK16/sm3)	1,88		
Internal rate of return		**IRR**	**IRR**
After-tax cashflow		24 %	24 %
Reserves		**mmboe**	**mmboe**
Oil production		26,4	26,4
Gas production		42,3	42,3
Cost level (real)		**mill NOK**	**mill $**
Total income		25 233	3 700
CAPEX		3 490	512
OPEX / TARIFFS /EXPLORATION		3 989	585
Abandonment		335	49
= CF before tax		17 419	2 554
- Tax payments		13 191	1 934
= CF after tax		4 228	620

Minimum economic volume:

~40% of base profile

= ~28 mmboe (2,7 Bcm gas & 10,7 mmbbl cond.)

Unconsolidated (stand-alone)

Unconsolidated tax approach (stand alone)		**mill NOK**	**mill $**
After-tax cashflow	10,00 %	957,2	140,4
Oil price (USD16/bbl)	70		
Gas price (NOK16/sm3)	1,88		
Internal rate of return		**IRR**	**IRR**
After-tax cashflow		19 %	19 %
Reserves		**mmboe**	**mmboe**
Oil production		26,4	26,4
Gas production		42,3	42,3
Cost level (real)		**mill NOK**	**mill $**
Total income		25 233	3 700
CAPEX		3 490	512
OPEX / TARIFFS /EXPLORATION		3 989	585
Abandonment		335	49
= CF before tax		17 419	2 554
- Tax payments		13 519	1 982
= CF after tax		3 900	572

Minimum economic volume:

~55% of base profile

= ~38 mmboe (3,7 Bcm gas & 14,5 mmbbl cond.)

6. Conclusions

The PL797 license is attractive to LEPN. It is located in a favorable position within proven plays and close to existing infrastructure. Ina is a relatively large gas-condensate prospect located close to the Mikkel Field. The Ina and Jaana prospects consist of stacked reservoirs in the Garn-, Ile- and Tilje Formations. The license work program has improved the understanding of the prospects significantly thorough internal and external studies. The structures are well defined on seismic and the reservoir potential for the formations are good at this depth. The main risk is the trap that depends on the sealing capacity of a North-East to South-West striking fault with a throw of approximately 100 meters.

The operator recommended applying for a license extension to do PSDM processing of the seismic data to improve the evaluation of the sealing potential of the fault in order to de-risk the Ina prospect. It is the operators view that it would be beneficial for the license to apply for an area extension towards the North to better understand the Jaana prospect and include this area in the PSDM processing. However, the partners did not support this approach, and a majority decision to drop the license was made.