PL1112 Status Report

Norske Shell

2024

Partners:

DNO Norge AS

Vår Energi ASA

Sval Energi AS

CONTENTS

1. PL1112 HISTORY

PL1112 is located on the Sklinna Ridge, Norwegian Sea, some 40 km west of the Njord Field. The license area covers parts of blocks 6406/7, 8, 10 and 11 (Ref. Fig. 1). The license was awarded to A/S Norske Shell (Operator 40%), DNO (20%), Neptune Energy Norge AS (now Vår Energi Norge ASA, 20%), Spirit Energy Norway AS (now Sval Energi AS, 20%) with effect from 19.02.2021. The first license milestone was a Drill or Drop decision to be taken 19th February 2022.

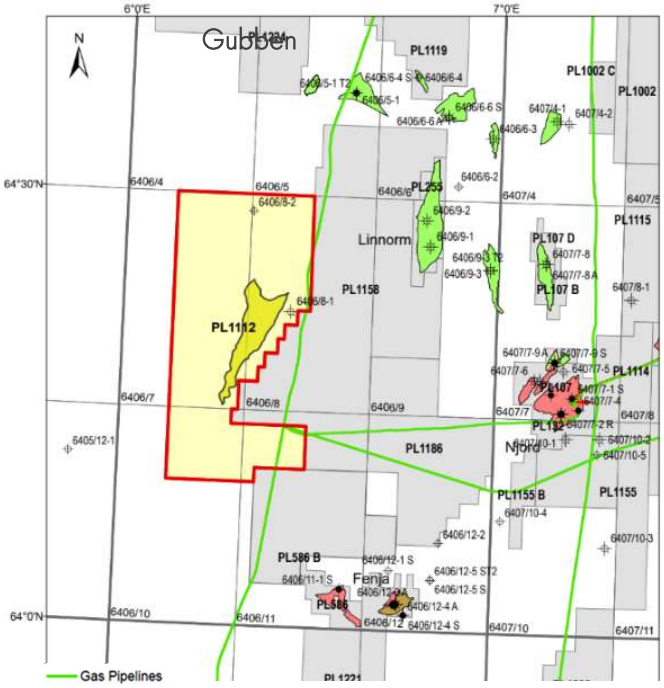


Figure 1. *PL1112 location map, combined Ile, Tofte and Tilje outline of Gubben prospect.*

During the studies of the 1-year commitment work programme it became clear that the seismic data was not of adequate quality for seismic inversion nor performing well planning and execution of drilling. Reprocessing was deemed necessary, and the license decided to apply for a 2-year extension of the Drill or Drop decision, extending it from Feb. 2022 to Feb. 2024. An extension was granted by the authorities.

After the re-evaluation of the Gubben prospect with new data, including results from inversion and technical and economic evaluations, the operator proposed a decision to drill the Gubben prospect (MC meeting #4, 05.12.2023). This however was not supported by the partners. They did not agree to the well cost estimate and requested further evaluation of development solutions after the operator's recent exit from the license containing Linnorm discovery, which was regarded as the main tie-in option for Gubben.

Hence the license applied for, and was granted, a 6-month extension for the license milestones with new deadline for Drill or Drop on the 19th August 2024. After detailed well planning and further evaluation of development scenarios with options for evacuation of the hydrocarbons, the operator proposed a drill decision 29 July 2024. This was again not supported by the partners which did not find the project economics sufficiently attractive. As the majority of the partnership did not want to continue to the next phase involving drilling an exploration well, the partnership agreed to a license lapse.

Discovery/ Prospect/ Lead name [1]	D/ P/ L [2]	Case (Oil/ Gas/ Oil&Gas) [3]	Unrisked recoverable resources [4]						Probability of discovery [5] (0.00 - 1.00)	Resources in acreage applied for [%] [6] (0.0 - 100.0)	Reservoir		Nearest relevant infrastructure [8]	
			Oil [10^6Sm^3] (>0.00)			Gas [10^9Sm^3] (>0.00)					Litho-/ Chrono-stratigraphic level [7]	Reservoir depth [m MSL] (>0)	Name	Km (>0)
			Low (P90)	Base (Mean)	High (P10)	Low (P90)	Base (Mean)	High (P10)						
Gubben-Ile	P	Gas	0.11	0.51	1.04	3.26	13.90	27.30	0.30	100.0	Ile Fm/ Middle Jurassic	4000	Njord	39
Gubben-Tofte	P	Gas	0.08	0.27	0.51	2.32	7.30	13.10	0.30	100.0	Tofte Fm/ Lower Jurassic	3950	Njord	41
Gubben-Tilje	P	Gas	0.08	0.25	0.44	2.35	6.60	11.40	0.30	100.0	Tilje Fm/ Lower Jurassic	3950	Njord	42
Gubben-Triassic	L	Gas	0.12	0.38	0.70	3.76	10.70	19.20	0.09	100.0	Red Beds/ Triassic	3950	Njord	43
Gubben-Basement	L	Gas	0.01	0.10	0.21	0.26	2.73	5.84	0.02	100.0	Basement	4100	Njord	44
Huginn-Rogn	L	Oil	0.52	3.01	5.65	0.10	0.60	1.13	0.14	100.0	Rogn Fm/ Upper Jurassic	4225	Fenja	35
Huginn - JM/JL	L	Gas								100.0	Ile Fm/ Middle Jurassic	4450	Njord	35
Huginn-North Rogn	L	Gas								95.0	Rogn Fm/ Upper Jurassic	4100	Njord	39
Evelix-KU	L	Gas								100.0	Lysing Fm /Upper Cretaceous	3450	Njord	42

Table 1. *Resource table from APA application.*

Status of work commitment

The work commitment in the first 1-year phase consisted of G&G studies which involved seismic stack fix to remove RMO impact, interpretation update and depth conversion. Furthermore, sedimentological, structural geology and petrophysics review was carried out as part of a prospect re-assessment and volume update. The economic evaluation was updated.

In the first extension period (2-years) seismic reprocessing was carried out along with new horizon interpretation, depth conversion and seismic inversion. Reservoir parameters, hydrocarbon column heights and recovery factors were reviewed and updated all resulting in new volumes and risk feeding into the technical and economic evaluations.

In the second extension period (6 months), detailed well design and well cost were made and alternative development concepts and economic evaluations.

License meetings

The following PL1112 meetings have been held:

17.02.2021	WM #1	
15.04.2021	EC/MC meeting #1	
24.06.2021	WM #2	
13.09.2021	WM#3	
29.11.2021	EC/MC work meeting #2	
07.04.2022	WM#4	
30.09.2022	WM#5	
23.11.2022	EC work meeting #3	
28.04.2023	WM#6	-Discuss feasibility for 2024 well
02.06.2023	WM#7	-Gubben volume update
27.10.2023	WM#8	-Concept and economic case for Gubben
05.12.2023	EC/MC meeting #4	-DoD recommendation

30.01.2024	WM#9	-Agree way forward
06.05.2024	WM#10	-Well design, cost status, and way forward
20.06.2024	WM#11	-Update on well design and cost

2. DATABASE OVERVIEW

Well database

Wells used in the technical evaluation and resource assessment for the license area are shown in table 2 and figure 2.

Well name	Common name	NPDID
6406/1-2	Sklinna	4762
6406/2-3	Kristin	2849
6406/2-7	Erlend	3878
6406/5-1	Tott East	4451
6406/6-2	Onyx West	5359
6406/8-1	Gubben	1136
6406/8-2	Hans	5435
6406/9-1	Linnorm	4927
6406/9-2	Linnorm	5454
6406/9-3	Onyx South	7141
6406/11-1S	n/n	1539
6406/12-3S	Fenja	7322
6406/12-3 A	Fenja	7432
6406/12-3 B	Fenja	7464
6407/9-1	Draugen	133
6407/9-2	Draugen	449

Table 2. *Well database – offset wells used in evaluation of PL1112.*

Seismic database

2D and 3D seismic data were used in the evaluation of the prospect and leads. The main dataset was PGS18M05. A summary of the seismic utilized in the evaluation of PL1112 is shown in table 3 and figure 2.

2D			3D			
Survey name	operator/owner	NPDID	Survey name, 3D	Underlying surveys for PGS18M05	operator/owner	NPDID
OLE2003	PGS Nopec	4207	PGS18M05	PGS15005	Multiklient Invest AS	8183
MNR04	TGS	4252		PGS14005	Multiklient Invest AS	8054
MNR05	TGS	4298		PGS14002	PGS	7993
MNR06	TGS	4364		HVG2013	Multiklient Invest AS	7900
MNR07	TGS	4450				
MNR08	TGS	4571				
MNR09	TGS	7001				
MNR10	TGS	7224				
MNR11	TGS	7389				
KFW98	Nopec/TGS	3912				

Table 3. *Seismic database – 2D and 3D seismic data used in the evaluation of PL1112.*

Reprocessing was done as part of the license work resulting in the dataset PGS15005SHR22, with underlying data from parts of PGS15005 (627 km^2) covers the Gubben prospect (Fig. 2 c). A subset of this (255 km^2) centered on Gubben was reprocessed for HiDef to be used in shallow geohazards evaluation.

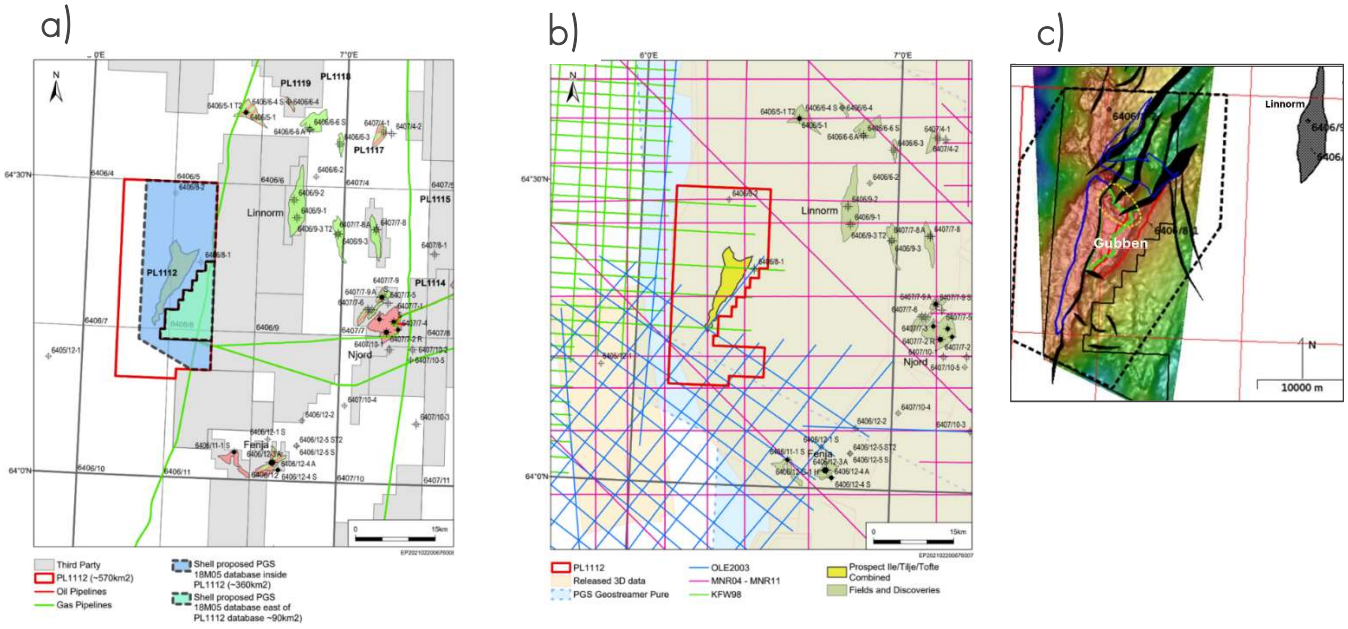


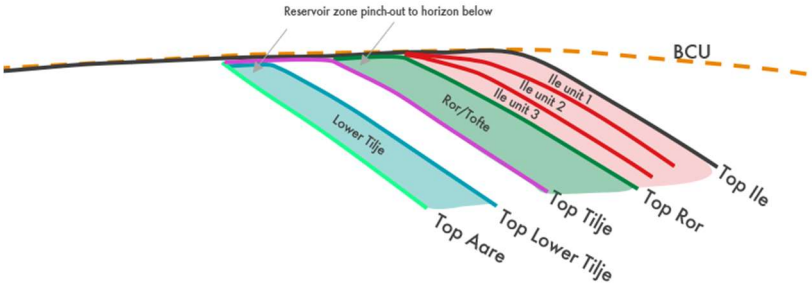
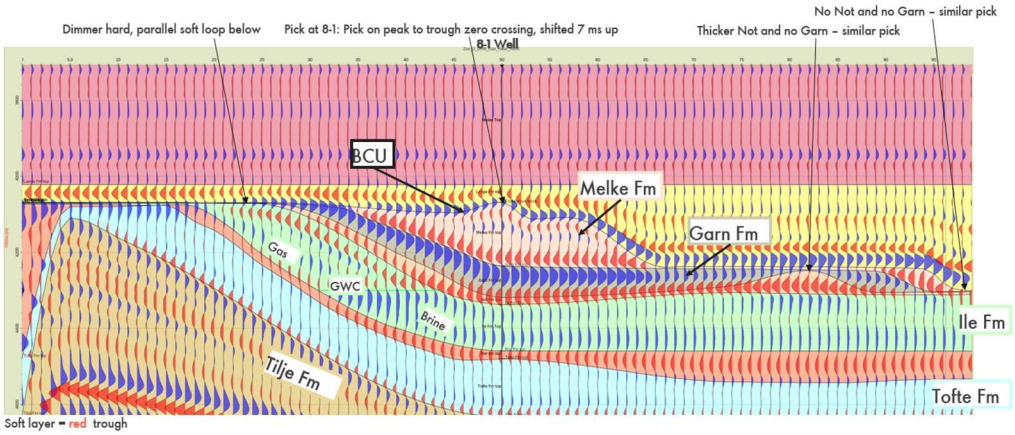
Figure 2. *Seismic data used in evaluation: a) 3D surveys, b) 2D lines, c) reprocessed dataset outline (PGS15005SHR22, dashed line).*

3. RESULTS OF GEOLOGICAL AND GEOPHYSICAL STUDIES

The following G&G studies were carried out in the license evaluation:

Table 4. *Summary of studies and results*

Study	Comments & Results
Seismic stack fix	-Initial effort to improve PGS18M05 data: reduction of RMO impact providing more reliable data for seismic quantitative interpretation.
Sedimentological, petrophysics and structural review	- Firming up view on depositional environment and parameters used in volume estimation and basin modelling.
Initial seismic interpretation on the PGS18M05 dataset, well modelling and AVO	-Revising interpretation for improved prospect definition and update of volume estimate. -Detailed well tie and AvO behaviour show possibly correlation to higher perm layer in Ile Fm.
Reservoir conditions	PVT evaluation of water samples from 6406/8-1 done to establish CO_2 range for the HC gas leg. Recovery factors were compared to results for simulating low permeability reservoirs for Linnorm field. Ile Formation was divided into 3 subzones to allow for variation of recovery factor within this formation.
Re-processing and velocity model update	Seismic re-processing of subset of PGS15005 dataset including seismic velocity model update. The processing resulted in an improved dataset which was to be used for more robust horizon and fault interpretation and especially improve the quality to attempt to achieve more robust seismic quantitative interpretation including inversion. Furthermore, the associated velocity model update helped addressing a low velocity anomaly related to a gas cloud above the prospect. HiDef processing was also done to be prepared for shallow hazards evaluation for well planning.
Seismic QI	The reprocessed seismic showed improved AvO behavior and image quality and allowed for a series of QI studies. These studies included scenario based forward modelling, attribute analysis and elastic inversion – resulting in a QI modification of Ile and Tilje POS as well as input to volumes. Main QI results for Ile formation: ■ A DHI was observed in the seismic data, both on Near and Far stack amplitude products. The expectation for the success case reservoir property range and full saturation gas was for a medium strength DHI to be observable. ■ The seismic response from the good to moderate quality Ile sandstone encountered by the nearby 6406/8-1 well can be mapped confidently up to the crest of the prospect, but some mapping ambiguity at the truncation with the BCU at the crest of the structure. ■ There is significant ambiguity in the seismic response between reservoir quality variations and fluid fill. Therefore, the structural conformance in the expected seismic amplitude response for a DHI carries a strong weighting in the scenario ranking. ■ The QI evaluation supports a scenario with good reservoir quality with brine and a depth conformable porosity increase or a scenario with good reservoir quality with fully saturated gas as most likely. The level of confidence is medium because of the moderate seismic data quality at target and the expectation of a moderate strength DHI for full saturation gas. This has led to a POS upgrade from 30% to 37%. Reservoir properties is not influenced by QI analysis due to the ambiguity in the seismic response between reservoir quality and fluid fill. Column height is influenced by QI, using the DHI at 4322m TVDSS to define the P10 column height.

	Main QI results for Tilje formation: ■ No evidence of a DHI was observed in the seismic data. The expectation for the success case reservoir property range and full saturation gas was for a medium strength DHI to be observable. ■ The seismic response from the good quality Lower Tilje sandstone encounter by the nearby 6406/8-1 well can be mapped confidently up to the crest of the prospect. ■ There is significant ambiguity in the seismic response between reservoir quality variations and fluid fill. Therefore, the absence of structural conformance in the expected seismic amplitude response for a DHI carries a strong weighting in the scenario ranking. ■ The QI evaluation supports good reservoir quality with brine fluid fill as most likely while good reservoir quality with fully saturated gas is considered unlikely. The level of confidence is medium because of the moderate seismic data quality at target and the expectation of a moderate strength DHI for full saturation gas. This has led to a POS downgrade from 30% to 22%. Reservoir properties and column height (post-commercial cut-off) are not influenced by QI analysis due to the ambiguity in the seismic response between reservoir quality and fluid fill.
Update of horizon and fault interpretation, volume and POS revision	The interpretation of prospect specific horizon and faults were revised on the reprocessed dataset. (Top Ile unit 2 and 3 were constructed from isochores). Column height estimation was revised and recovery factors were adjusted based on analogues. This resulted in manifesting the view on Ile Fm. as the main reservoir for volume contribution. Ile Fm. also came out as the most attractive from a POS perspective with POS uplift from seismic evaluation.  Fig 3. *Schematic of remapped key surfaces for Gubben prospect and construction of reservoir zones for volume calculation.*  Fig 4. *Example from 2D modelling – checking seismic response with different formation/lithologiy interfaces and fluid fill to aid interpretation.*

Subsurface basis for well design and well cost estimation	Pore pressure prediction, overburden hazards evaluation and formation top estimation was carried out and fed into the well design work which was then used in well cost estimates.
Economic evaluation	Development options and cost estimation using latest versions of subsurface work provided basis for economic evaluation used in reaching the drill or drop decision.

4. PROSPECT UPDATE REPORT

The focus for the PL1112 license has been the Gubben prospect. This is a 2-way dip, fault and truncation bounded trap with the main potential in the middle to upper Jurassic, coastal – fluvio-deltaic – deltaic deposits of Tilje, Tofte and Ile formations. The formation layers are dipping to the east of a basement high (Sklinna Ridge) and truncated by the Base Cretaceous Unconformity towards and over the high. Some additional volume potential is represented by a wedge of possibly Triassic age next to the basement high, and in the basement high itself if of a fractured nature (Fig 5), but these involve considerable risk and uncertainty. The structure is sealed by Lower Cretaceous marine shales of the Lange Fm. Charge is believed to be mainly from gas mature Åre formation coals to the east (similar charge as for Linnorm). Presence of liquids however cannot be excluded if contribution from oil mature Spekk formation onlapping in the east or juxtaposed to the west of the basement high. This seems to require a more tortuous migration route.

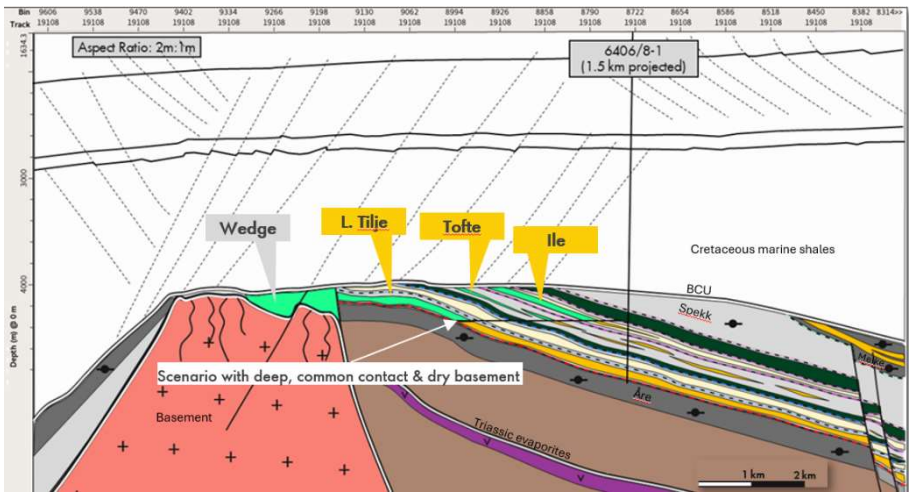


Figure 5. *Schematic cross section, east to west orientation. Green colour fill indicate gas filled reservoir in an arbitrary common contact scenario.*

The well 6406/8-1 was drilled on the flank of the structure in an earlier license, PL131. Although classified as dry the well proved presence of sandstone in the three formations, Ile, Tofte and Tilje (lower Tilje). Two well tests were carried out, one over Lower Tilje and one over Ile formation. While the Tilje test did not flow and indicated tight formation, the Ile flowed water with some dissolved gas. The well test and core measurements show relatively low permeabilities. In the Ile formation the permeability is generally <1 mD in the upper and lower part but is higher in a 30m middle unit with scattered measurements between 1 and 10 mD and a couple up to 50-60 mD especially within a 7 m interval. There is speculation whether widening of an Ile-internal seismic loop could mean that this thin interval expands up-dip towards the crest of the structure. Producibility from the Gubben reservoirs remains a concern.

In addition to reservoir quality, a key uncertainty is related to the seal strength and the length of hydrocarbon column that could be retained. Several structures in this area have short hydrocarbon columns due to breached seal. A gas cloud is located above part of the structure. Study of offset wells and the 8-1 well data provided basis for adjusting the view on column heights during the study phase and the updated volume calculations are based on more constrained hydrocarbon column estimates. For the Ile formation, the estimated P10 contact is associated with the seismic anomaly at 4322m potentially related to hydrocarbon presence. This is also close to the Ile WUT (4337m) seen in the 8-1 well. (See fig. 6 for depth map and contacts.) The P50 contact however, is by operator estimated shallower, at 4160m, and is related to expected seal strength derived from fracture gradients and gas/pressure gradients.

The crests of the different Gubben reservoirs are not vertically stacked but located laterally to each other (fig. 5). Testing for hydrocarbons in each potential trap can therefore not be achieved by a single vertical well.

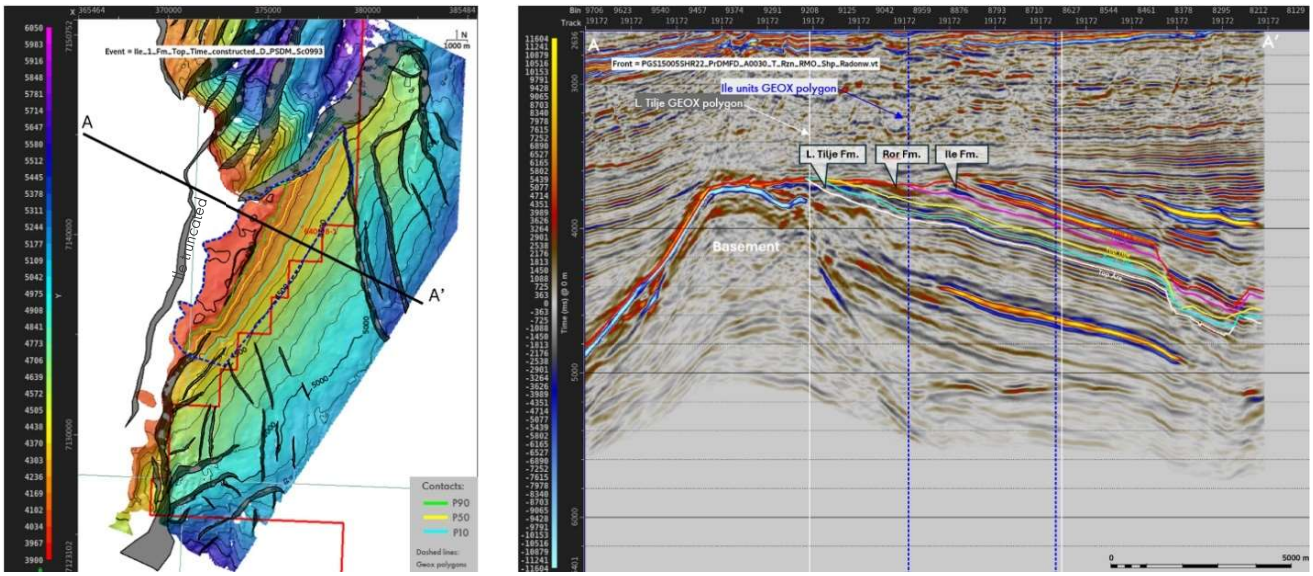


Figure 6. *Top Ile Formation depth map and seismic section with key Gubben prospect surfaces.*

	Parameter	Units	Mean/MSV	P90	P50	P10	POS
Ile	GIIP	BCM	47	22	42	80	37
	Gas Rec.	BCM	19	6.6	16	35	
Tofte	GIIP	BCM	8.8	1.5	5.8	21	22
	Gas Rec.	BCM	4.7	0.5	2.8	11	
L. Tilje	GIIP	BCM	13	1.3	4.6	39	22
	Gas Rec.	BCM	7.6	0.6	2.7	23	

Table 5. *Updated volumes and POS after completion of studies.*

There is an additional play in the Upper Jurassic Rogn formation. The potential reservoir of the Huginn-Rogn lead is linked to any late uplift and erosion of the Sklinna Ridge and could be sourced by eroded Lower-Middle Jurassic, Triassic and Basement material which redeposited down flank. The main lead applied for was not included in the award, some potential still exists to the north in the PL1112 license, however with low POS and not currently attractive.

5. TECHNICAL ASSESSMENT

Several options for development have been considered for PL1112. The concepts evaluated range from subsea tieback to Linnorm, direct tieback to shore, standalone development, developments integrated with other discoveries and tieback to Njord. The focus for the technical assessment has been development of the Ile reservoir volumes. The base case development concept leading into the final drill recommendation was a subsea tieback development to Njord with 3 production wells. With this concept it is anticipated that Kårstø will have enough CO2 blending capacity from early 2030's. Both dry and wet gas scenarios were considered for the development case. The recovery mechanism assumed is by natural depletion and gas expansion drive with some pressure support from the aquifer. The operators expected net present value result in a positive economic potential.

6. CONCLUSION

The evaluation of the Gubben prospect has shown considerable remaining uncertainty in the volume range associated with possibility for a breached seal and poor recovery factors. Several well penetrations at HPHT conditions are required to test the various parts of the full Gubben prospect. The Ile reservoir is from the studies estimated to have the best potential and the operator proposed a well with target in this part. Agreement on whether the Gubben prospect could be economically developed however was not reached in the partnership and a decision was made to let the license lapse.

Attachment

Updated prospect data forms.