PL 999- Licence status report

Summary

PL999 is located on the Frøya High, 7 km SW of the Njord Field. The partnership and equity are Equinor (operator) 70% and Neptune 30%.

The licence was awarded 01.03.2019 and the DoD decision expires 01.03.2022. Work commitments are fulfilled including reprocessing of 3D seismic and G&G studies. Due to late delivery of the reprocessed 3D seismic data, a one-year extension was approved in 2020.

The initial exploration concept of the PL999 licence was to explore for hydrocarbons matured in the kitchen in the Gimsian Basin, and then migrated through the Vingleia fault complex and onto the Frøya High.
Several studies have been undertaken with special focus on the Triassic and basement play. The new seismic processed PGS14005EQRZ20 added new insights of the subsurface understanding. A semi regional structural reinterpretation of the Frøya high was carried out on the new 3D seismic and extended using the vintage PGS14005. This gave a reduction in the in-place volumes of the Greasbyr Triassic and Pennsbyr, renamed to Greasbyr basement prospects. The main causes of this volume reduction are the improved structural definition of the Cretaceous- basement interface, a better definition of spill point and improved imaging. The reprocessed seismic showed that the Greasbyr apex to the south, was in fact basement and not Triassic as believed initially. On the upside, the new 3D seismic revealed a new early Triassic/ late Permian prospect within the licence, named Padderokk (figure 1). This prospect is, however, associated with very high reservoir and trap risk.

An updated basin model show that considerable hydrocarbon volumes have been generated in the basin to fill the prospects. Hydrocarbon shows in 6407/10-4 and 6407/10-3 prove that hydrocarbons are migrating through the Vingleia fault complex, and that the PL999 prospects are situated in a favourable position in terms of charge. Unfortunately, the combination of high trap/seal risk and expected poor reservoir properties, leaves the defined prospects with a low probability of success. In addition, the Reprocessed PGS14005EQRZ20 AVO study conclude that there is no resolution to support any Direct Fluid Indicators (DFI) in Greasbyr or Padderokk with the expected reservoir and overburden properties.

Table of contents

Contents

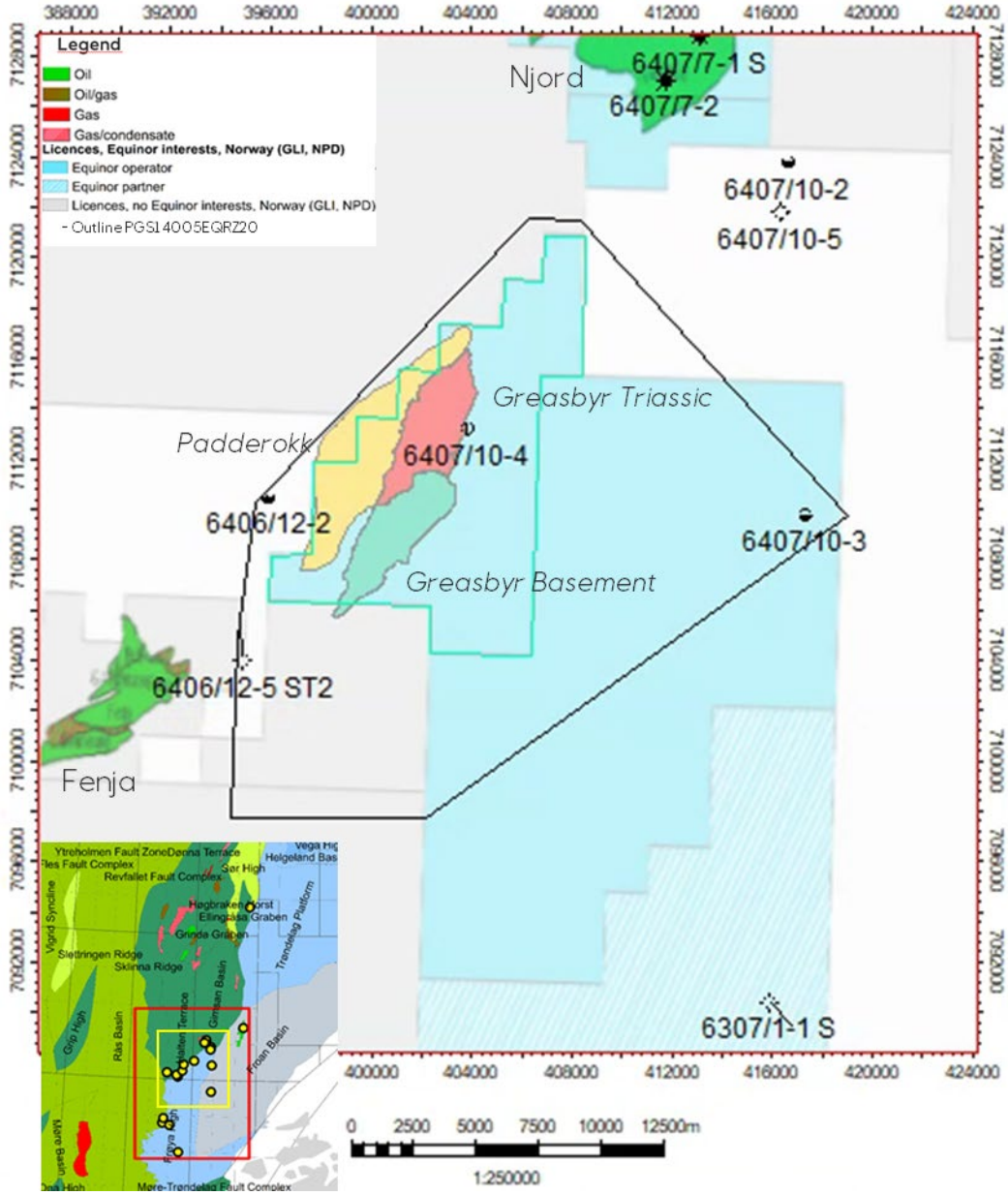

Figure 1: *Area map with PL999 licence outlined in cyan, Fenja and Njord fields, Greasbyr & Padderokk prospects and surrounding exploration wells.*

1 Licence history

Licence: PL999

Awarded: 01.03.2019 (APA2018)

Licence period: Expires 01.03.2026
Initial period: 7 years

Licence group:

Equinor Energy AS	70% (Operator)
Neptune Energy Norge AS	30%

Licence area: 104.132 km^2

Work programme: Reprocessing 3D Seismic data and G&G studies - Fulfilled

Meetings held:

25.04.2019	EC/MC meeting #1
08.05.2019	EC work meeting #1
20.08.2019	EC work meeting #2
13.11.2019	EC/MC work meeting #2
02.06.2020	EC/MC work meeting #3
22.09.2020	EC work meeting #3
04.12.2020	EC/MC meeting #4
02.07.2021	EC work meeting #4
01.11.2018	EC/MC meeting #5

Work performed:

2019-2020:

- Reprocessing and Geological studies. PSDM reprocessing from field tapes of a subset of the PGS14005 acquisition. Interactive and interpretation driven workflow.
- Feasibility study of refraction velocity mapping of Cretaceous/ Triassic/ basement interfaces conducted.
- Interpretation of new regional structure maps. The Greasbyr prospect definition was improved, divided into a basement and Triassic segment. The Padderokk prospect mapped and detailed.
- A 3D density inversion conducted.
- A Petroleum Systems Analysis and Basin model (PSA model) was updated for the Frøya High to improve predictions of expelled volumes from upper Jurassic source rocks.

2021-2022:

- Interpretation of the reprocessed seismic dataset at several play levels.
- Basement reservoir evaluation, detailed fault and fracture evaluation.
- Integrated petrophysical evaluation of the 6407/10-4, 6407/10-3 and 6307/1-1S wells.
- Semi regional tectonic and structural evaluation of the Frøya High with special focus on the Triassic evolution.
- Seismic angle migration using GRT. Fracture and fault analysis on Seismic diffraction volumes.
- 6407/10-4 Stoneley waveform and 6407/10-4 borehole image logs.
- AVO analysis of reprocessed datasets.
- Further Refinement of PSA model.
- Updated prospect evaluation of the Greasbyr and Padderokk prospects.

Cause of relinquishment:

A substantial amount of technical work has been carried out on the Frøya High focused on the PL999 area. A complete re-mapping of the stratigraphy from basement to mid Cretaceous was carried out. PSDM reprocessing from field tapes and additional angle migration including diffraction imaging was done to improve structural imaging and improve resolution. Detailed fracture and fault analysis was also performed. Petrophysical study of relevant wells and sedimentological work indicate poor reservoir properties and uncertainty of an intra Triassic seal, result in a low probability of any economical hydrocarbon accumulations in the identified PL999 prospects.

2 Database overview

The PL999 licence common database was approved after ECMC meeting #1, initially containing wells, 2D seismic and one 3D seismic survey (PGS14005). In 2020, the common database was updated to include the reprocessed PGS14005EQRZ20 dataset. See Figure 3 below.

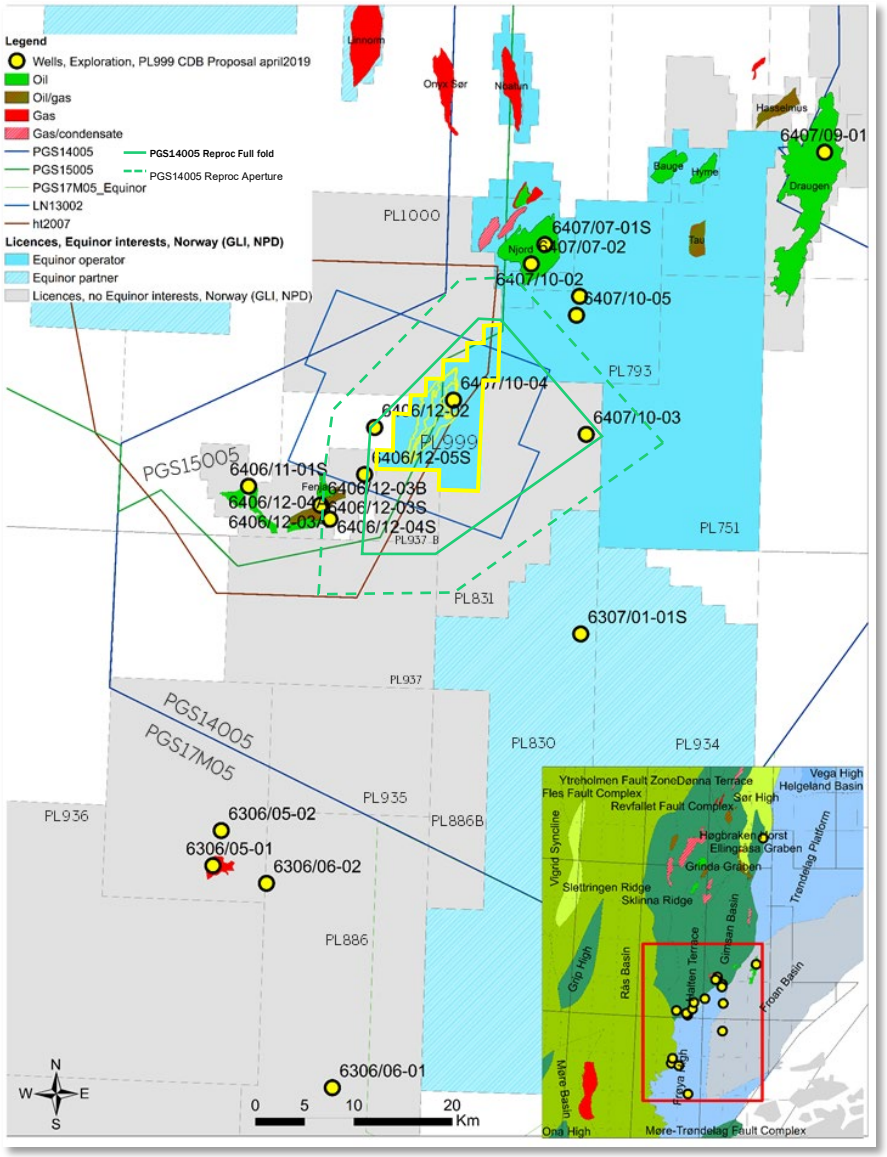

Figure 3: *Common database PL999 as per 2021.*

2.1 Seismic data

The seismic data that was utilized in the final PL999 technical evaluations are shown in Table 1.

Table 1: *Seismic data included in the PL999 common database*

Dataset	NPID	Quality
PGS14005	8054	Good
PGS14005EQRZ20	8054	Excellent
MC3D-HT2007	4447	Poor
PGS14005 PSDM 2015 Vint	8054	Good

2.2 Well data

The well database utilized in the PL999 technical evaluations area is listed in Table 2. Wells 6407/10-4 & 6407/10-3 are both penetrating the Triassic strata and crystalline basement on the Frøya High. They were used for well ties and fluid substitution modelling. Wells 6406/12-2 and 6407/12-5 ST2 were used for well ties and basin model building.

Table 2: *Wells included in the PL834 common database*

Well name	NPID	Well name	NPID
6306/5-2	7726	**6407/7-1 S**	474
6306/6-1	2384	**6407/7-2**	1017
6306/6-2	6143	**6407/7-3**	1229
6307/1-1 S	8523	**6407/9-1**	133
6406/12-2	2640	**6407/9-7**	1057
6406/12-3 S	7322	**6407/10-1**	1054
6406/12-3 A	7432	**6407/10-2**	1497
6406/12-3 B	7464	**6407/10-3**	1927
6406/12-4 S	7721	**6407/10-4**	7699
6406/12-4 A	7774	**6407/10-5**	7763
6406/12-5 ST2	7787	**6507/12-2**	6191

3 Results of geological and geophysical studies

Geological and Geophysical studies

The main G&G study conducted in the licence was the reprocessing of PGS14005. In parallel to this project a refraction study and a 3D density inversion study was conducted. This was partly to aid the velocity model building and to identify areas that could provide improved reservoir properties. In addition to conventional interpretation and identification of leads and prospects in PL999, a semi regional structural interpretation with restoration of isolated sections was performed. This was necessary to understand the evolution of the Frøya High and the structural complexity of the northern part of the basement high. The last study performed in the licence was a Stoneley wave and borehole image interpretation. This was done to evaluate the potential for presence of an open fracture system within basement lithologies at the well location. The conclusion of the study was that there are fractures and small-scale faults in the basement and lower Triassic, but the there is only a small probability that these are open and can provide free flow of fluids.

Seismic reprocessing

Based on legacy reprocessing projects using the PGS14005 as input, the PL999 partners decided to reprocess the data from field tapes. The PGS14005 is a geostreamer acquisition and it was believed that the effects of P-up generation impacted the pre-processing and de-multiple processing negatively. The need for improved control

of the input data and the ability to correct the spectrum early in the processing flow, was identified as a key success factor. Improved control of the input data early in the processing flow enabled a focussed de-noise, de-bubble and model building process. Improved resolution, amplitude control and imaging were the main objective. Even though the main objectives of this reprocessing were achieved, the improved resolution was not adequate to resolve intra Triassic or basement AVO effects. The structural image was greatly improved because of a strengthened de-multiple flow, extensive model building flow including velocity scanning. In addition, all major steps in the processing flow were fully 3D migrated using a predefined fast forward flow for quality control. This enabled the partners to identify processes in the flow that could lower the quality of the final product.

Features in the input dataset that were not easily revealed in the vintage PGS14005 stacks, were the seismic interference (SI) contamination of the field data turned out to be substantial. The level of SI noise was so severe that field data refraction velocity analysis could not be used. This was an Equinor R&T analysis, and together with a 3D density inversion using gravimetry and magnetic field data the objective was to isolate sweet spots in the Triassic and basement play. The licence had to rely on the density inversion alone, although some information from the full waveform inversion (FWI) model building could be used.

In addition to conventional KPSDM and KPSTM migration cubes a set of angle migration (GRT) cubes were produced. This migration algorithm provides very good quality in terms of structural imaging, amplitude preservation and the parameterization can be tuned to enhance the S/N ratio. The same migration algorithm also provides diffraction volumes, and this was a good addition to identify fractures and small-scale faults along the interface between the Cretaceous to the Triassic and Triassic to basement. The strength of this imaging product is its data driven nature and resolution compared to other methods like ant-track and thin fault likelihood.

3D seismic interpretation

A substantial work program was conducted with respect to 3D seismic interpretation and following AVO and rock physics analysis, attribute analysis, fault and fracture analysis. The PGS14005EQRZ20 survey was used together with the vintage PGS14005 to get a regional understanding of the PL999 and the surrounding area. The conclusions of the seismic interpretation efforts are mainly the following:

(1) Confirmation of basement high with high tectonic activity in the Permian and Triassic. Several erosional events were identified in the late Permian and the Triassic. Reservoir presence in the early Carnian is of relatively high confidence due to the vicinity of 6407/10-4 well. Due to the absence of analogue well data on the Frøya High, reservoir properties within the older Triassic strata are more speculative and expected to be poor.
(2) New seismic reveals that near the crest of the Greasbyr prospect, the crystalline basement is truncated by an upper Jurassic unconformity below the Spekk Formation. No indications are observed for presence of upper Jurassic sandstones within the Greasbyr prospect.
(3) Low confidence of existing intra Triassic seal from interpretation. Well observation suggests that this exist, however beneath seismic resolution.
(4) Fault and fracture analysis suggest highly fractured top basement, however Stoneley wave and borehole image analysis conclude that the fractures are not open at the 6407/10-4 well location.
(5) High confidence in continuous permeable pathways from the kitchen to the prospect area
(6) No signs of hydrocarbons (gas) in the AVO cubes, hydrocarbons in oil phase are unresolved due to the AVO signal, resolution and S/N ratio (Triassic)
(7) No gas chimneys within PL999

(8) Reprocessing confirms observations volcanic activity that can be linked with a SE-NE trend towards 6307/1-1 S well (Silfari).

(9) No signs of locally present Permian or Triassic mature source rocks in the seismic. The conclusion of the seismic interpretation work is that there are no signs of locally matured hydrocarbons within PL999.

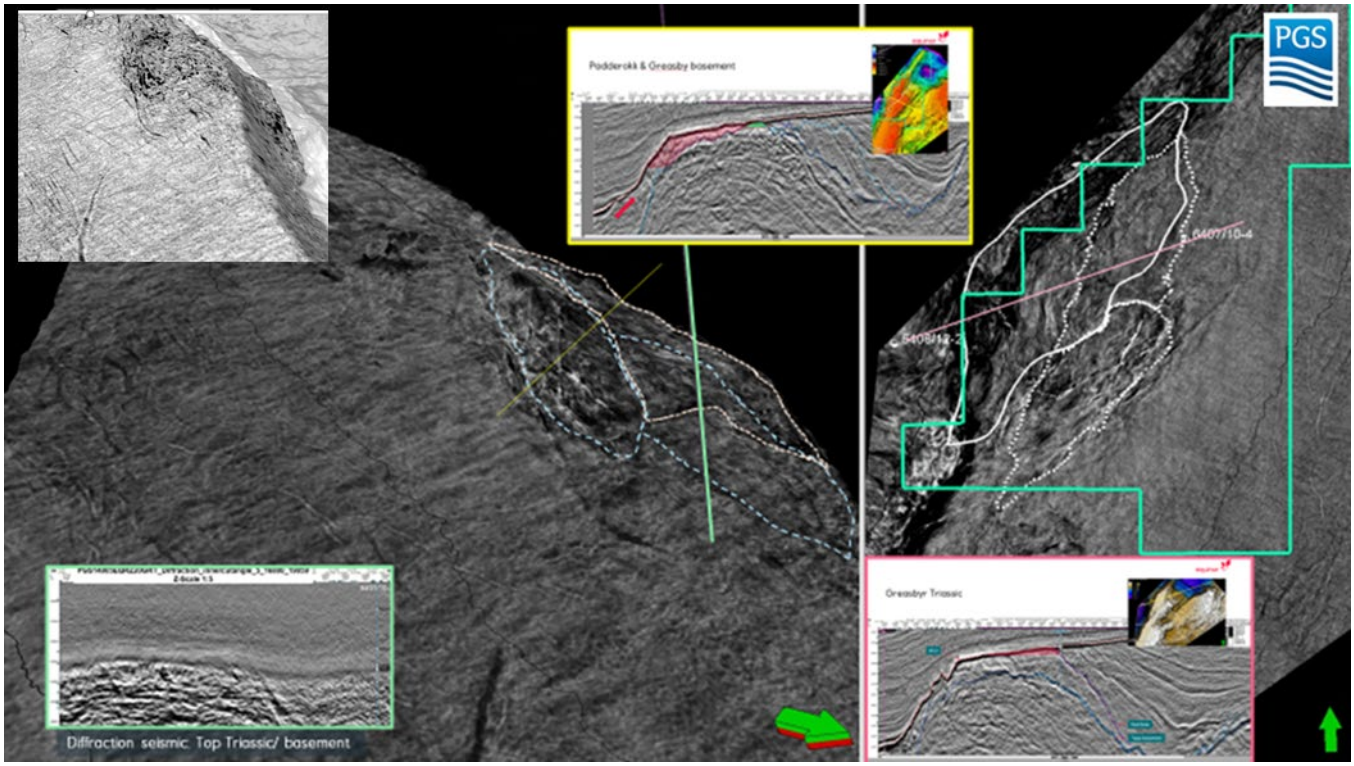

Figure 5. *Top Triassic merged with top basement surface with diffraction amplitudes summed +2 to -6 msec. Clear lineaments and fracture sets over Greasbyr basement segment. Possible late Triassic channels west of PL999. Seismic survey PGS14005, curtesy of PGS.*

4 Prospect update report

A geological sketch illustrates the prospective intervals and key elements (Figure 6).

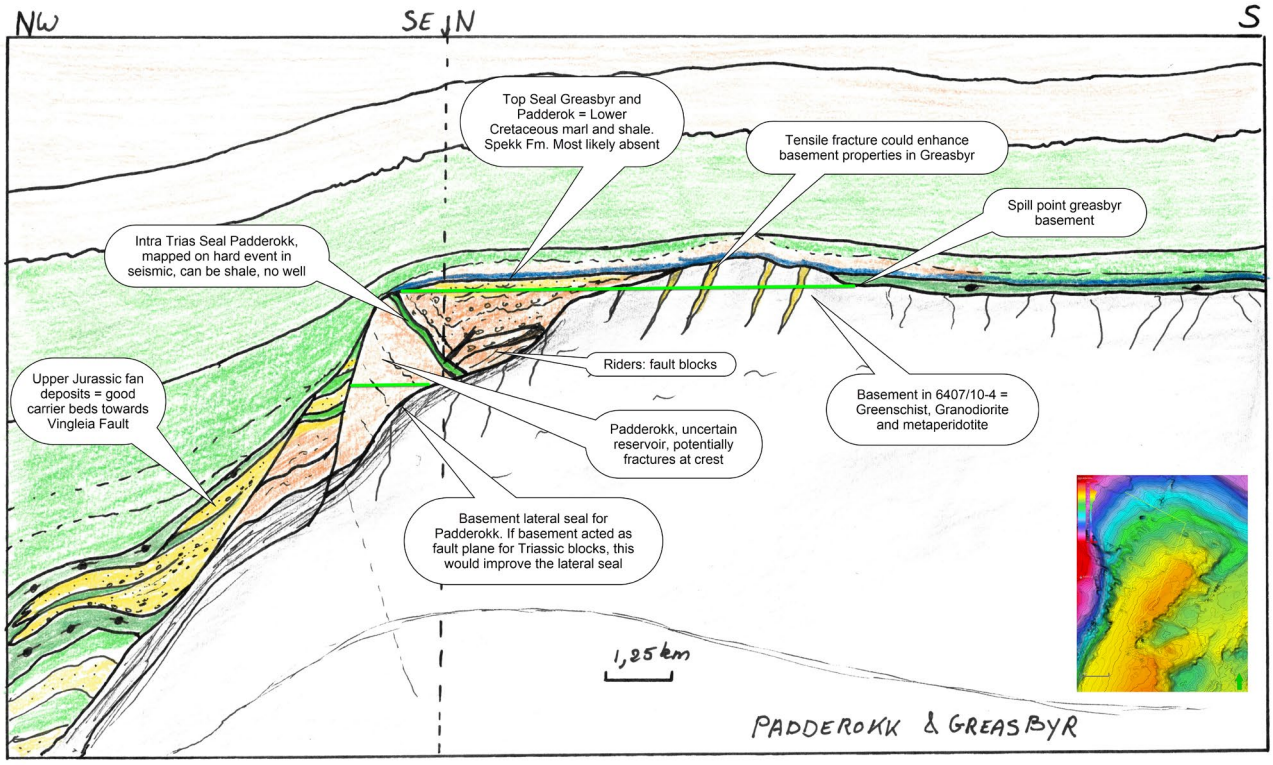

Figure 6. *Conceptual sketch Padderokk and Greasbyr illustrating key elements for the Padderokk and Greasbyr prospects*

Greasbyr prospect

The Triassic and basement Greasbyr prospect are located on the Frøya high. On the very edge of the northern footwall of the Vingleia fault complex. The prospect is approximately 7 km SW of the Njord Field. Originally the Greasbyr prospect was thought to be a Triassic closure with possible upper Jurassic Rogn sandstones and Spekk overburden. Reprocessed seismic reinterpretation more confidently shows that the prospect is divided into two segments, the northern part according to early interpretation and a basement southern part. No proof of upper Jurassic sandstones is found, although high contrast of cretaceous and Triassic/ basement lithology will overprint any thin sandstone layers at this interface. Upper Jurassic sands cannot be disregarded, although there is no confidence in a thicker upper Jurassic package.

Greasbyr trap definition

The maximum filling of both the Triassic and basement container is controlled by the 6407/10-4 well and a sealing Triassic N-S fault west of the well. A filling of the Greasbyr Triassic cannot be deeper than 2469m which corresponds to the depth of the intra Triassic top seal observed in the 6407/10-4 well. A deeper filling would have been discovered in 6407/10-4. The Greasbyr basement deepest contact is controlled by a spill point towards the south which coincides with a depth of 2469m. As there are no seismic or well observations supporting the presence of a working seal between basement and Triassic strata, both segments are believed to be controlled by the same elements. In addition to the max filling of 2469m, the trap needs a working intra Triassic W-E fault seal in addition to a Cretaceous top seal.

Minimum risked column (P100):
Early Carnian Fm. 89m, basement 60m

Maximum risked column (P0):
Early Carnian Fm. 108m, basement 460m

Reservoir
The expected reservoir interval within the Greasbyr Triassic segment is drilled in the 6407/10-4 well at 2469m TVD MSL. The petrophysical evaluation concludes that poor to moderate quality sandstones are to be expected. The porosity ranges between 13-16% and the permeability skews towards the low side.

The basement segment is expected to be non-producible with porosities of ~1-3%. Well 6407/10-4 penetrated the basement and the lithology is originally classified as metasandstones and conglomerates. The well observations and comparisons of analogues at Lancaster and Utsira along with diffraction imaging analysis and ant tracking, lead to the conclusion of a non-producible basement segment.

Source presence & maturity
The primary source rock for the Greasbyr prospect includes the known source rock of the Upper Jurassic Spekk and Melke Fms matured in the Gimsan Basin. Detailed work on available charge volumes from the fetch area in the Gimsan Basin demonstrates that significant volumes have been generated to charge the Greasbyr prospects.

Hydrocarbon migration
Migration is not regarded as a key risk for prospects within the PL999. The presence of a functioning kitchen area is the Gimsan Basin is proven by the Fenja Field in the SW, the Njord Field in the NW and shows in 6406/12-2. The migration of hydrocarbons onto the Frøya high is proven by shows observations in the 6407/10-4 and 6407/10-3 wells. Even though the migration route towards the well observations is still debatable, a clear migration pathway within upper Jurassic sandstones immediate down flank the PL999 licence is envisaged as the most likely case. As the identified traps in PL999 are structurally set along the fault, any migration paths onto the high along this stretch will fill the Padderokk first and if an intra Triassic or basement seal is absent, then the Greasbyr prospect will be filled. The expected low permeability to tight properties of the late Permian and early Triassic can still act as a migration path because fractures and small-scale faults are present in addition to potential weathering effects along the late Jurassic paleo exposure of the High itself.

HC phase
The hydrocarbon phase is believed to be oil, based on the PSA model, observations from Fenja and Njord and lack of a clear gas response from the AVO analysis. Risk is attached to this assumption as gas discoveries in Triassic and basement settings on the Utsira High neither can be resolved by AVO.

DFI
DFI was inconclusive due to seismic resolution, S/N ratio and sediment/ basement contrasts.

Additional prospectivety

Table 3 summarizes the total licence prospectivety within PL999. Figure 1 shows the identified prospectivety of PL999.

Table 3: *Additional prospectivity PL999, including Greasbyr prospect*

	Recoverable mmboe						Risked volumes mmboe
Prospect / Segment	**P100**	**P90**	**MEAN**	**P10**	**P00**	**Pg**	
Greasbyr							
Greasbyr Triassic	16	23	38	55	82	14	5.32
Greasbyr Basement	1	2	15	32	63	15	2.25
Padderokk							
Padderokk early Triassic	3.26	7.47	34	72	156	8	2.72

Padderokk Prospect

The Padderokk prospect is defined by a tilted fault block located on the north-western edge of the Frøya High. The prospect is laterally bounded by an intra Triassic shale to the north and NE and the Vingleia fault in the west. The shales from the Spekk Formation and Cretaceous act as top seal and basement as base seal. Seal and reservoir quality are the major risks of the prospect. Based on its structural setting with respect to the Greasbyr prospect and the 6407/10-4 well, the expected reservoir within the Padderokk prospect is early Triassic and/or older in age. The equivalent section in Padderokk is not drilled elsewhere in the area and there are no direct well observations of an intra Triassic shale at this level. The seal is identified on seismic, and a continuous reflector can be interpreted. The basement is penetrated by the 6407/10-4 and is classified as metasandstones/conglomerates and schists. The basement has potential to be a good seal, although cracks, small faults and weathering will impact the quality.

The Padderokk prospect shows some analogies with the Triassic discoveries on the Utsira high. However, due to the depth of the prospect and the tectonic history, the expected reservoir is of relatively poor quality. Low porosity and permeability are to be expected and the beds are highly inclined with a dip of approximately 60°.

Minimum risked column (P100):
Late Permian/ Early Triassic 95m

Maximum risked column (P0):
Late Permian/ Early Triassic 350m

The Padderokk prospect is believed to be in a favourable position in terms of source and charge. A mature kitchen is present directly in the basin towards the west. The Spekk Formation is estimated to be the major generator of hydrocarbons, however the Melke Formation is also considered a possible contributor. The structure is the first potential trap that hydrocarbons encounter as they migrate from the basin and up the Vingleia Fault.

5 Technical evaluation

Due to low volume estimates and lack of reservoir, no technical evaluation was performed after APA 2018.

6 Conclusion

The Triassic and basement play was the main driver for the PL999 licence. Greasbyr Triassic was the main driving prospect in the licence, however reprocessing of the PGS14005 showed that a major part of the volumes was in basement rocks and low chance of success. The Padderokk prospect was defined based on the new seismic and the container had promising volumetrics. After the G&G evaluation the Padderokk prospect was found to be of early Triassic age or older. The estimated reservoir properties showed to be non-commercial. The decrease of volumes in Greasbyr and non- commercial properties in Padderokk, lead the PL999 partnership to the decision of relinquishing the PL999 licence.