PL 127 B Licence status report

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1 Key licence history

Licence: PL 127 B

Awarded: 06.02.2015

Licence period: Expires: 06.02.2025
Initial period: 10 years

Licence group:

Equinor Energy AS	50% (operator since 30.11.2018)
Aker BP ASA	50% since 30.11.2018
Total E&P Norge AS	50 % until 30.11.2018 (operator)

Licence area: 42 km^2

Work programme: Decide to drill, initially by 06.02.2017

1. Extension to 06.02.2018, main reason: PL 127 C carve out
2. Extension to 06.02.2019, main reason: establishing a semi-regional rock physics model
3. Extension to 06.02.2020, main reason: await Black Vulture wildcat well in PL 159 B
4. Extension to 06.02.2021, main reason: prospect re-evaluation based on reprocessed seismic data (EQ19M01) and Black Vulture discovery results
5. Extension to 06.02.2022, main reason: await Black Vulture appraisal well in PL 159 B

Meetings held:

11.11.2015	EC/MC meeting	04.04.2019	EC work meeting
14.06.2016	EC/MC meeting	13.12.2019	EC/MC meeting
17.11.2016	EC/MC meeting	01.07.2020	EC work meeting
19.12.2017	EC/MC meeting	16.12.2020	EC/MC meeting
07.06.2018	EC work meeting	30.06.2021	EC work meeting
24.01.2019	EC/MC meeting	26.11.2021	EC/MC meeting

Work performed:

2015:	Extending G&G evaluation from PL127 into PL 127 B area
2016-17:	Screening and Maturation of Cretaceous and Jurassic prospectivity
2018-19:	Change of partner- and operatorship, reprocessing of seismic data, re-evaluation of Cretaceous and Jurassic prospectivity
2020:	Geophysical evaluation of Black Vulture discovery (PL 159 B) and implication for Cretaceous prospectivity in PL127 B
2021:	Updating Cretaceous prospects based on Back Vulture appraisal well result and screening of Jurassic targets
2022:	Decision to surrender the licence

Reason for surrender:

Prospectivity was evaluated and re-evaluated on several seismic data sets, including EQ19M01, for which reprocessing focussed on data quality improvement of the Cretaceous interval. The original Cretaceous Brugde lead turned out to consists of two prospects, Black Vulture and Hooded Vulture. Both prospects were of economic interest, until the Black Vulture appraisal well (6507/3-14 T2) in PL 159 B encountered sandstones with only residual hydrocarbon saturation of moderate to poor reservoir quality within the area of most promising seismic amplitude anomalies. It proved that the Black Vulture discovery is not extending into PL 127 B; and it significantly lowered the expected volume potential in Hooded Vulture and decreased its chance of success. Several small prospects were identified within the Jurassic succession, but all too small to be considered for future production. Hence, the remaining prospectivity within the licence is not of economic value and it was unanimously decided to surrender the licence.

2 Database

2.1 Seismic data

Three seismic data sets have mainly been used to evaluate the licence prospectivity throughout the last 7 years, namely ST11M01, MC3D-HVG2012, and EQ19M01. Within the common data base polygon (Figure 1), the ST11M01 dataset compromises underlaying data of six surveys, while the underlying data for EQ19M01 comprises three different datasets, listed in Table 1 together with their NPDID numbers.

Seismic data set	Underlying seismic surveys*	NPDID
ST11M01		
	ST9203	3561
	ST9301	3625
	ST9717	3892
	MC3D-DTW2000	4047
	EN0804	4551
	MC3D-NON2010	7238
MC3D-HVG2012	-	7616
EQ19M01		
	MC3D-DTW2000	4047
	MC3D-HVG2012	7616
	PGS16005	8321

Table 1: *NPDID numbers of seismic data*
**underlying surveys within the PL 127 B common seismic data base*

2.2 Well data

The common well database comprises the Black Vulture appraisal well 6507/3-14 T2 (completed in 2021) and public available data from released wells including Alve N, Alve NE, Black Vulture, Cape Vulture and Jette discoveries (Figure 1). The NPDID numbers of the key wells are listed in Table 2.

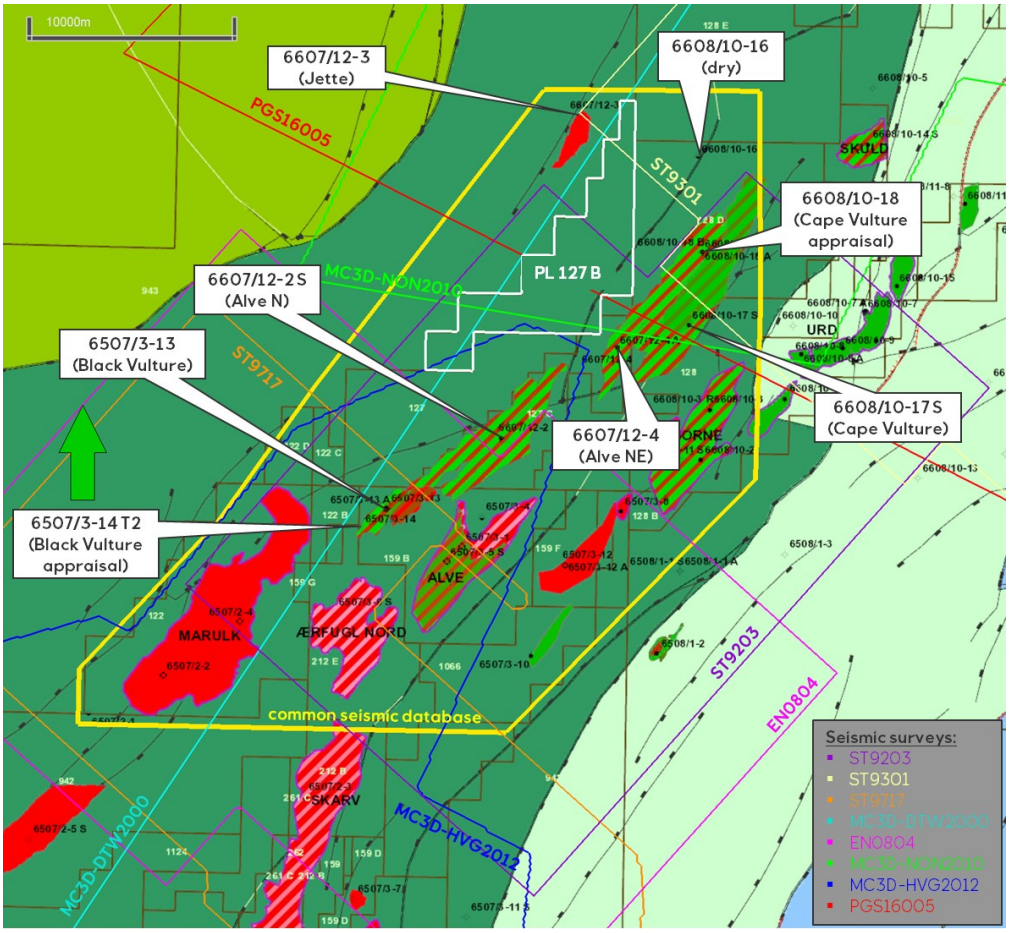

Figure 1: *Overview map with location of the licence area (white polygon), common seismic database (yellow polygon), seismic surveys in different colours, and annotation of the key wells*

Well number	Discoveries	NPDID
6507/3-13	Black Vulture	8720
6507/3-13 A	Black Vulture	8721
6507/3-14 T2	Black Vulture appraisal	9318
6607/12-2 S	Alve N	6642
6607/12-3	Jette	7039
6607/12-4	Alve NE	9077
6607/12-4 A	Alve NE	9078
6608/10-16	dry	7404
6608/10-17 S	Cape Vulture	8065
6608/10-18	Cape Vulture appraisal	8506
6608/10-18 A	Cape Vulture appraisal	8507
6608/10-18 B	Cape Vulture appraisal	8508

Table 2: *NPDID numbers of key wells*

3 Review of geological framework

The prospectivity of the Cretaceous interval has been the main business driver for the licence work, though Jurassic targets have been screened in addition.

Cretaceous sandstones are mainly deposited on the Dønna terrace in a deep marine setting as turbiditic seafloor fans and slope deposits. The reservoir quality is varying substantially both laterally and vertically, depending on proximity to source and flow axes. Several Cretaceous discoveries have been made on the Dønna Terrace within the last decades. Sandstones of the Lysing formation have been proven to be gas bearing in many locations and the formation is produced both at the Marulk and Ærfugl fields, whereas sandstones of the Lange Fm. of various ages have been encountered to be both gas and oil bearing. Producibility of these Lange Fm. sandstone reservoirs is challenging due to its heterogeneity and high content of clay minerals that negatively impact the flow potential.
Prospect identification is based on seismic amplitudes, which is not straight forward. Almost all sandstone layers are so thin that they are represented in the seismic data by a single cycle event; and tuning of the amplitudes is a major factor. Thus, several characteristics of the Lange sandstones are contributing to seismic amplitude brightening and dimming, namely variation in thickness, porosity, clay content, and fluid changes. Since hydrocarbons are migrating through these sandstones, trapping of residual gas is not uncommon, which causes amplitude effects that are difficult to differentiate from areas with high saturation of hydrocarbons.

The Lysing Fm. seems not to form any traps within the PL127 B licence, neither structurally nor stratigraphically. Seismic amplitudes that typically indicates hydrocarbon accumulation in sandstones of the Lysing Fm. are not observed in the various seismic datasets, supporting the conclusion that there are neither prospects nor leads to be found in PL 127 B.

The licence G&G work has early shown, that the original Brugde lead in the Lange Fm. had to be split into two, the Black Vulture and the Hooded Vulture prospects, both extending outside the licence boundary (Figure 2A). The Black Vulture prospect was tested in PL 159 B by two wells, 6507/3-13 in 2019 (discovery) and 6507/3-14 T2 in 2021 (appraisal, dry). The Hooded Vulture prospect remains untested.

Jurassic prospectivity sits within the well-known Mid-Jurassic shallow marine sandstone deposits of the Fangst and Båt groups. These deposits are laterally extensive and relatively homogenous. Hydrocarbons in these formations are trapped in rotated fault blocks and horst structures. These reservoirs are produced in the vicinity of the licence at Norne and Alve since decades. Robust traps are mapped within PL127 B, but they are buried deeply and are too small to be of commercial interest (Figure 2B). Shallow targets within the Tertiary sedimentary package have not been identified, while traps below the Jurassic succession exist but are not considered to comprise functioning reservoirs due to heterogeneity, high shale content, and large burial depth.

Geological and geophysical studies included general 3D mapping, seismic reprocessing (EQ19M01, Figure 3), remapping and prospect screening, semi-regional rock physics modelling and quantitative seismic analyses, improvements of understanding the different depositional systems in Jurassic and Cretaceous times. All studies led to the conclusion that the potential of trapped hydrocarbons of economic interest was to be expected in the Black Vulture and Hooded Vulture prospects, until the Black Vulture appraisal well encountered sandstones with only residual hydrocarbon saturation in an area of strong seismic amplitude anomalies.

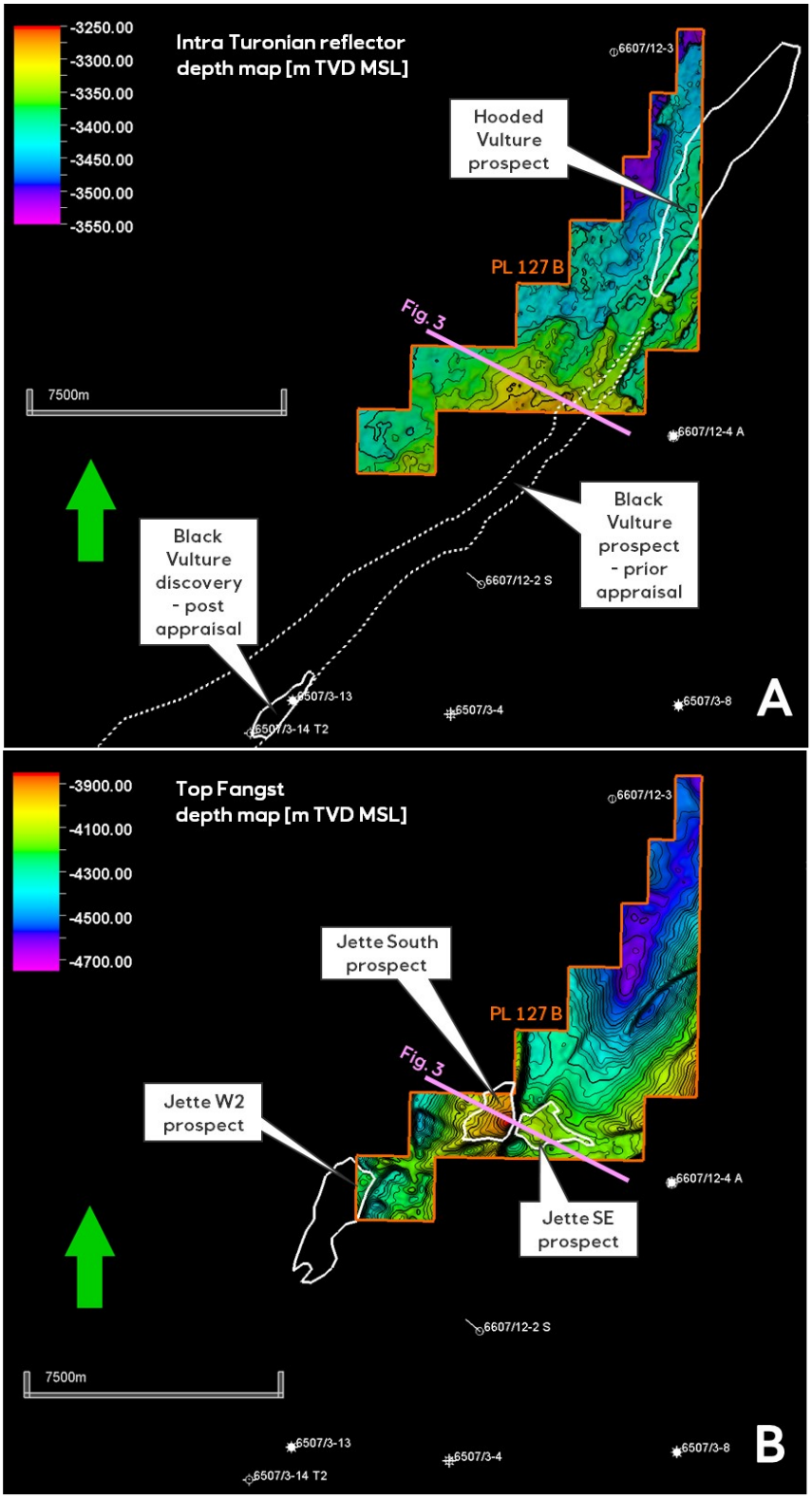

Figure 2: ***(A)*** *Intra Turonian reflector (Black and Hooded Vulture level) depth map,* ***(B)*** *Top Fangst depth map, prospect and discovery outlines in white, licence boundary in orange, common seismic database in yellow, location seismic section in Figure 3 marked in magenta*

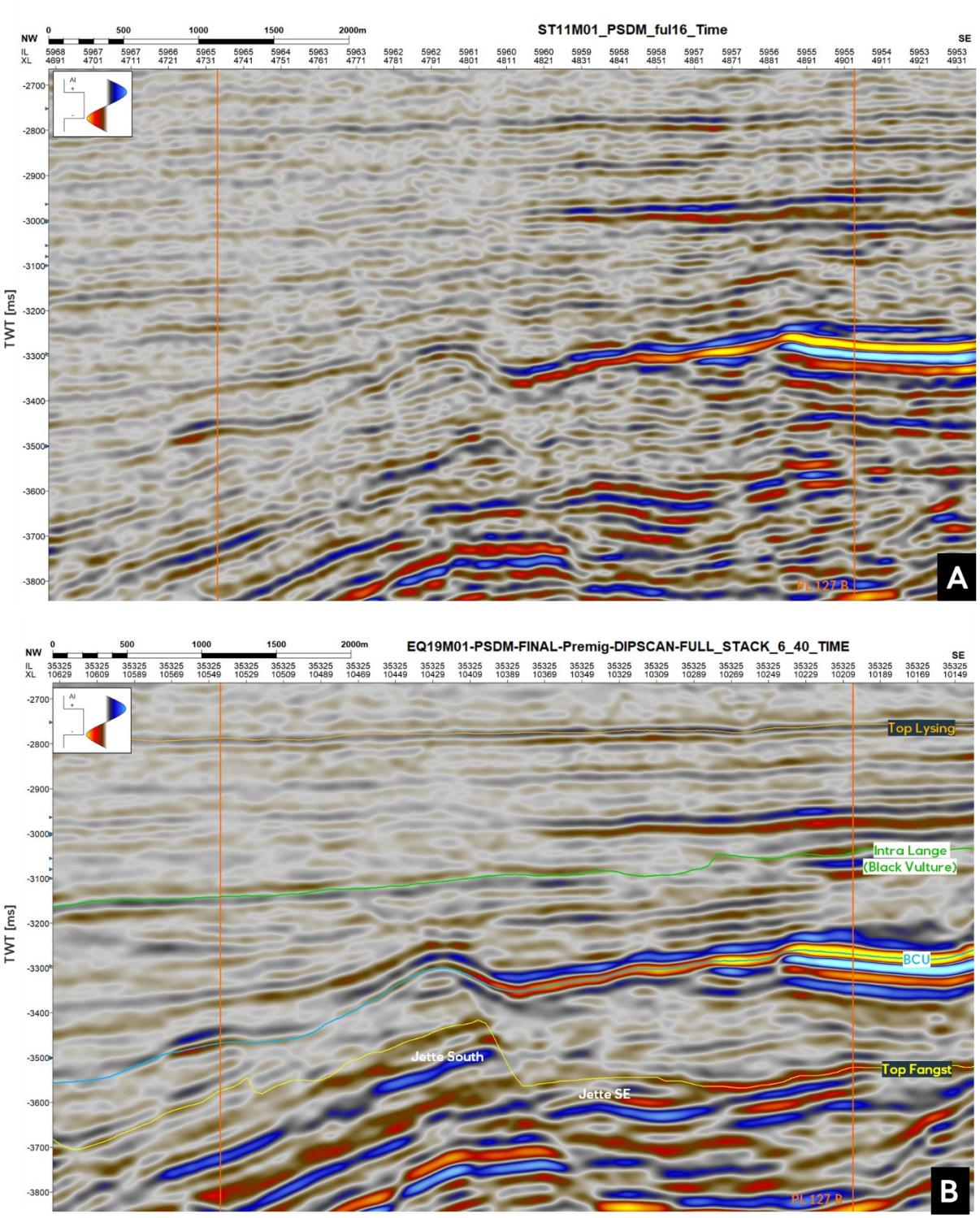

Figure 3: *Seismic section in two-way travel time, zero phase and normal polarity, NW-SE profile, as marked in Figure 2 in magenta;* ***(A)*** *ST11M01 final full stack;* ***(B)*** *EQ19M01 final full stack (zero phase, normal polarity) with interpretation of Top Lysing Fm. (orange), Intra Lange Fm. (Black and Hooded Vulture level, green), Base Cretaceous Unconformity (BCU, blue), and Top Fangst Fm. (yellow)*

4 Prospect update

4.1 Brugde lead and Black Vulture prospect

The lead in the APA application was named Brugde (Figure 4), which turned out to be two separate prospects at the same stratigraphic level, Black Vulture and the Hooded Vulture (Figure 2A). The Black Vulture appraisal well (6507/3-14 T2) in PL 159 B has proven that the seismic amplitude anomalies are not representing a connected high hydrocarbon saturated bearing sandstone system of large extent. It limits the actual Black Vulture discovery to a relatively small area entirely outside PL 127 B (Figure 2A). Both Black Vulture wells have shown that hydrocarbons have been migrating through this turbiditic depositional system and accumulations could be trapped in structural closures. However, no such traps of considerable dimension have been identified within the licence, except of the Hooded Vulture prospect.

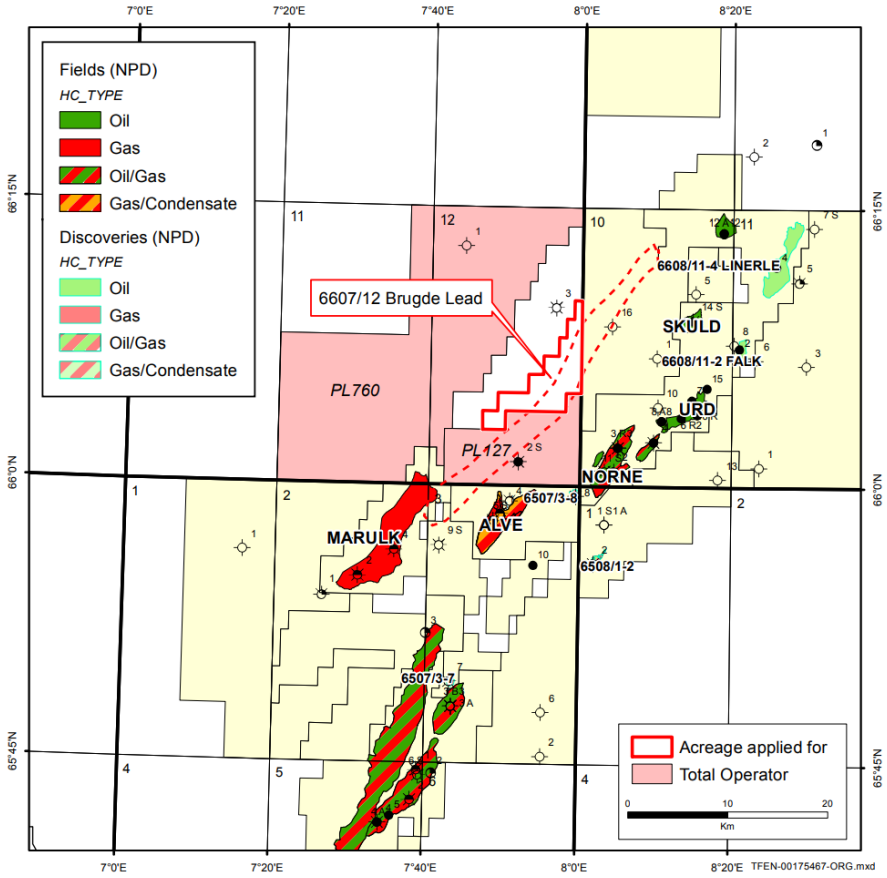

Figure 4: *Historic prospect map from licence application in 2014. The identified lead "Brugde" was later divided into the Black Vulture and Hooded Vulture prospects (Figure 2A).*

4.2 Hooded Vulture prospect

Reservoir

The prognosed reservoir in Hooded Vulture is the Cretaceous Intra Lange Fm. sandstones of Turonian to Late Cenomanian age, as encountered in the Black Vulture discovery. The reservoir is characterised by stacked turbidite lobe deposits with sandy turbidite channels. Best reservoir properties are associated with coarse grain lag deposits, while the turbidite lobe deposits possess moderate reservoir properties, and the debrite and low density turbidites possess poor reservoir properties.

Seal

The trap is evaluated as a structural 3-way closure with stratigraphic components.
The reservoir over- and underlaying basin floor shales of the Lange Fm. form an effective top and side seal, proven by several Cretaceous discoveries on the Dønna Terrace.

Source presence and maturity

Hooded Vulture is assumed to share a common source-migration history with Black Vulture. The source is presumable of Jurassic or Cretaceous origin that was of main- to late-oil maturity during the time of hydrocarbon generation.

Hydrocarbon migration and phase

Migration of hydrocarbons into Hooded Vulture is expected from south via the Black Vulture area. That Black Vulture is not filled to spill has a negative impact on the migration risk assessment, but it is not excluding this migration route.
The prospect could be charged with oil or gas.

Pressure and Temperature

Pressure in the Hooded Vulture is estimated to be 480 – 520 bar. Reservoir temperature is modelled to be 125 – 135°C based on the regional temperature gradient.

Direct fluid indication (DFI)

Seismic amplitudes are indicating a clear softening of the rock formation at the prospect, but it is not clear if this softening is caused purely by the characteristics of the sandstone deposits itself or in combination with hydrocarbon fill. It has not been possible to distinguish areas of the reservoirs that are highly saturated with hydrocarbons from those with residual saturation.

Volumes and probabilities

The in-place volume potential is estimated to be 0.4 – 7.0 MSm^3 o.e. in-place post Black Vulture appraisal well, at a geological probability of success of 17.1%, with the larges risk of trap seal. The recoverable resource potential of the remaining Hooded Vulture prospect is much smaller than the estimated resource potential of the Brugde lead prior licence application (Table 3 and Table 4). Notably, only the southwestern part (36.2 %) of the Hooded Vulture prospect lies within the PL 127 B licence (Figure 2A).

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)						
Brugde	P	Oil&Gas	7,30	22,90	42,20	2,01	6,10	11,30	0,16	25	Lange	3125	Norne/Polarled	25

Table 3: *Historic resource potential of the Brugde lead from licence application in 2014.*

Discovery / Prospect / Lead name (1)	D / P / L (2)	Case	Unrisked recoverable resources						Probability of discovery	Resources in acreage applied for	Reservoir		Nearest infrastructure	
			Oil 10^6 Sm3 (>0.00)			Gas 10^9 Sm3 (>0.00)					Litho-/Chrono-	Reservoir depth	Name	Km
			Low (P90)	Base, Mean	High (P10)	Low (P90)	Base, Mean	High (P10)						
6608/10 Hooded Vulture	P	Oil and gas							0.00		Lange Fm.	3370 m TVD MSL	Norne	10
		Oil	0.06	0.42	1.07	0.03	0.20	0.50	0.09	36.2 %				
		Gas	0.04	0.28	0.68	0.13	0.94	2.27	0.09	36.2 %				

Table 4: *Remaining resource potential in Hooded Vulture prospect in 2022*

4.3 Jurassic prospectivity

Three small Jurassic prospects have been identified within the licence, Jette South, Jette SE, and Jette W2, of which the latter only lies partly (10.8%) within PL 127 B (Figure 2B).

Reservoir

The prognosed reservoir in all three prospects are of the Middle Jurassic Garn and Ile formations, which were deposited in a predominantly tidally influenced deltaic setting. These sandstone deposits are laterally extensive and well developed over large areas of the shallow water Norwegian Sea. Offset wells that penetrated Garn and Ile formations, such as the wells at the Alve field, encountered producible reservoirs. However, those wells are shallower situated than these relatively deeply buried prospects, and the degree of quartz cementation is a decisive factor for producibility.

Seal

The reservoir overlaying shales of the Melke Fm. and the underlaying shales of the Ror Fm. are proven top and base seals in the region. All three traps are robust, either 4-way closures (Jette South and Jette W2) or 3-way closure (Jette SE) with a sealing fault against the adjacent prospect (Jette South).

Source presence and maturity

An Upper Jurassic Spekk Fm. source rock is considered the most likely candidate for charging these Mid-Jurassic prospects, as it is the main contributor of hydrocarbons to numerous fields and discoveries in the greater Nordland-Halten area. Additionally, the Upper Jurassic Melke Fm. could contribute hydrocarbons. Other source rocks could include Aptian to Albian aged marine source rock as well as the predominantly terrestrial Åre Fm. with its coal layers. All potential source rocks are either peak or late mature in the vicinity of the prospects.

Hydrocarbon migration and phase

The traps are expected to have been in place by Late Jurassic / Early Cretaceous times, while hydrocarbon migration is modelled to have taken place during the Cenozoic. The prospects have potentially been charged multiple times, presumably from the northwest. Gas has most likely replaced oil during the long timespan of migration, which might be ongoing until today. An oil charge cannot be ruled out but might turn out to be a failure case, if the reservoirs are tightly quartz cemented.

Pressure and Temperature

Pressure in these prospects is estimated to be above normal pressure in the range of 470 – 580 bar. Reservoir temperature is modelled to be 130 – 150°C, based on depth of the reservoirs and the well-known regional temperature gradient.

Direct fluid indication (DFI)

Direct fluid indications (DFI) have neither been observed in the seismic data, nor are they expected due to the depth of the prospects.

Volumes and probabilities

The volume potential in each of these prospects is very small. Even in a very optimistic scenario of finding 50 m of net reservoir, in-place volumes are estimated to be around 1.6 MSm^3 o.e. (Jette W2), 1.4 MSm^3 o.e. (Jette South), and 0.5 MSm^3 o.e. (Jette SE), with a geological probability of success between 60 to 80 %. Neither full prospect analyses nor recoverable resource estimations have been performed for these small Jurassic prospects.

5 Technical assessment

None of the prospects in the licence are evaluated to have volume potential that is large enough to be of economic interest. Therefore, no detailed technical assessment has been carried out.

6 Conclusions

The main motivation to extend the licence several times was to mature the Cretaceous Black Vulture prospect and its upside potential the Hooded Vulture prospect, both of the same stratigraphic level of Turonian to Late Cenomanian age. The Black Vulture prospect was tested in 2019 (discovery) and appraised in 2021 (dry) outside the licence boundary. The appraisal well proved that the Black Vulture prospect is not a connected high hydrocarbon saturated sandstone system that extends into PL 127 B. Furthermore, the combined well results of the Black Vulture discovery and appraisal have downgraded the Hooded Vulture prospect, both with regards to volume potential and probability of success.
Other prospect targets have been identified within the Mid-Jurassic play. These prospects are relatively small in extent, and they are deeply buried, leading to low volume potential. Their expected reservoir quality is low due to quartz-cementation caused by exposure to high temperatures.

None of the remaining prospects within the licence are evaluated to have volume potential that is large enough to be of economic interest, and the conclusion to surrender the licence was reached unanimously between the licence partners.