PL 1077 – Licence status report

Summary

PL1077 was formerly part of PL533 (Lundin operated) and was applied for in APA 2019. The license included acreage within the four blocks 7219/12, 7220/10, 7119/3 and 7120/1, and was located 45 km south of the Johan Castberg Field (Figure 1).

Two gas discoveries are located within and close to PL1077 (Figure 1). Well 7219/12-2 S, Hufsa, had a gas discovery in the Nordmela Formation and well 7220/10-1, Salina, encountered gas in Kolmule- and Stø formations. Both discoveries show a strong DFI response related to the proven gas, and it is expected that additional hydrocarbon filled prospects should have a similar strong DFI response. However, geological and geophysical evaluation on newly available high-quality 3D-data concludes that there is no DFI support for significant oil columns on any prospects within the license and no drilling candidates have been identified.

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1 Licence history

Licence:	PL1077	
Awarded:	14.02.2020	
License period:	Initial period: 14.02.2020 – 14.02.2022	
License group:	Equinor Energy AS	60 % (Operator)
	DNO Norge AS	40 %
License area:	285.547 km^2	

Work programme:
Acquire 3D-seismic, Geology- and geophysics studies.
Drill or drop decision within 2 years from award. Geological and geophysical evaluation of prospects has been finalized. Work obligation is fulfilled.

Meetings held:

20.05.2020	EC/MC startup meeting
22.10.2020	EC/MC meeting
04.08.2021	EC meeting
17.11.2021	EC/MC meeting

Work performed:
Since the award, high-quality seismic data LN17001 became publicly available and was used to conduct a full geological and geophysical evaluation of prospects.

Reason for surrender:
The license decided to let the licence lapse on the expiry of the initial period on 14.02.2022. Despite promising structures with good volume potential, no geophysical support for commercial hydrocarbon volumes have been detected. A strong DFI downgrade is applied in the risking giving overall a very high-risk picture reflecting our lack of belief in a commercial discovery. Further technical work is unlikely to resolve this.

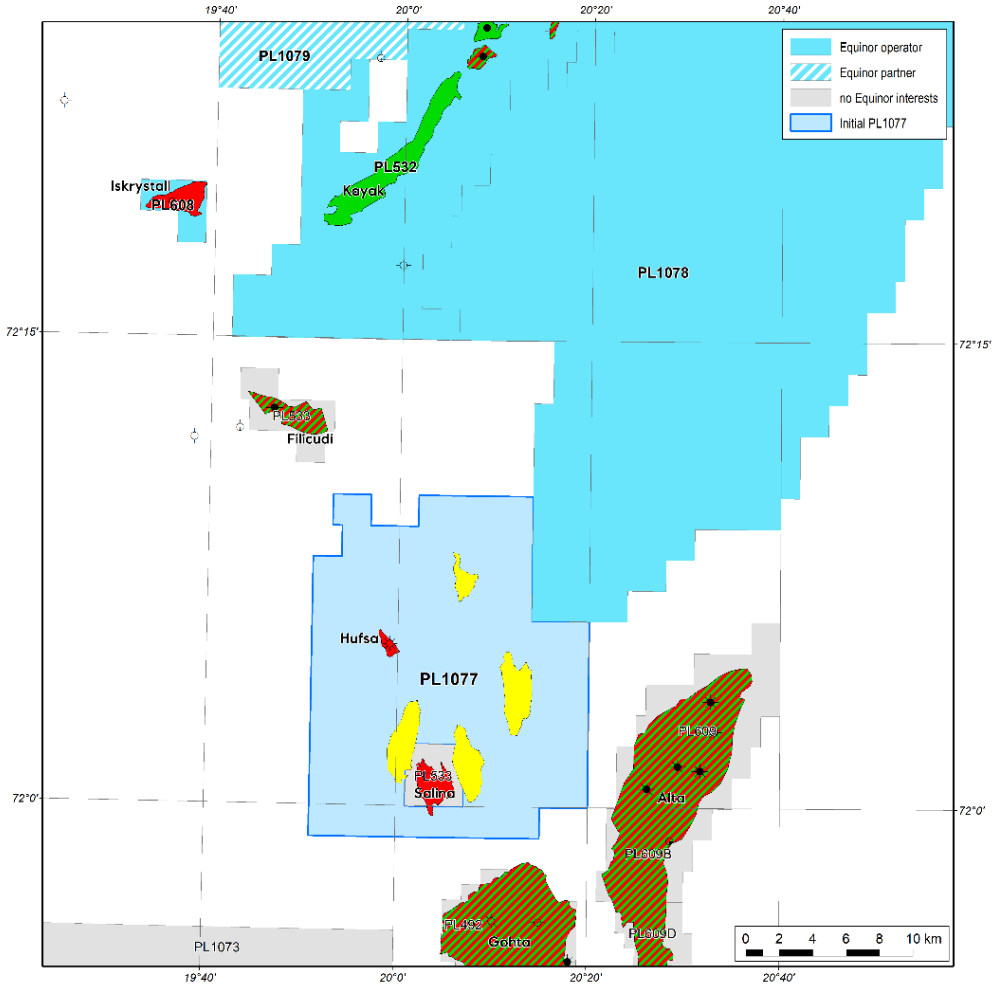

Figure 1. License overview showing PL1077 together with surrounding licenses. Remaining Jurassic prospects (yellow) within PL1077 are indicated.

2 Database overviews

2.1 Seismic data

The seismic database (Table 1) consists of released 2D data and two 3D-surveys covering nearly the entire license, apart from the southwestern corner. The 3D-surveys are LN0801, and the TopSeis data NL17001 which covers the northern part of PL1077 where data over Salina is excluded (Figure 2).

Seismic survey	Operator/Responsible	2D/3D	Year	Comment
LN0801	Lundin Norway AS	3D	2008	
LN17001	Lundin Norway AS	3D	2017	Reprocessed in 2019
NBR06	Fugro-Geoteam AS	2D	2006	
NBR07	Fugro-Geoteam AS	2D	2007	
NBR08	Fugro-Geoteam AS	2D	2008	
NBR10	Fugro Multi Client Services AS	2D	2010	
NBR11	Fugro Multi Client Services AS	2D	2011	
BARE05	NPD (Fugro)	2D	1973-1986	Reprocessed in 2005
NH8412	Norsk Hydro Produksjon AS	2D	1984	
LHSG-89	Den norske stats oljeselskap a.s	2D	1989	
NPD-TR-83	NPD	2D	1983	
NH8403	Norsk Hydro Produksjon AS	2D	1984	
NH8306	Norsk Hydro Produksjon AS	2D	1983	
NPD-BJSY-84	NPD	2D	1984	Reprocessed in 1997
SG9309	Saga Petroleum ASA	2D	1993	Reprocessed in 1999

Table 1. Overview of 2D and 3D seismic database.

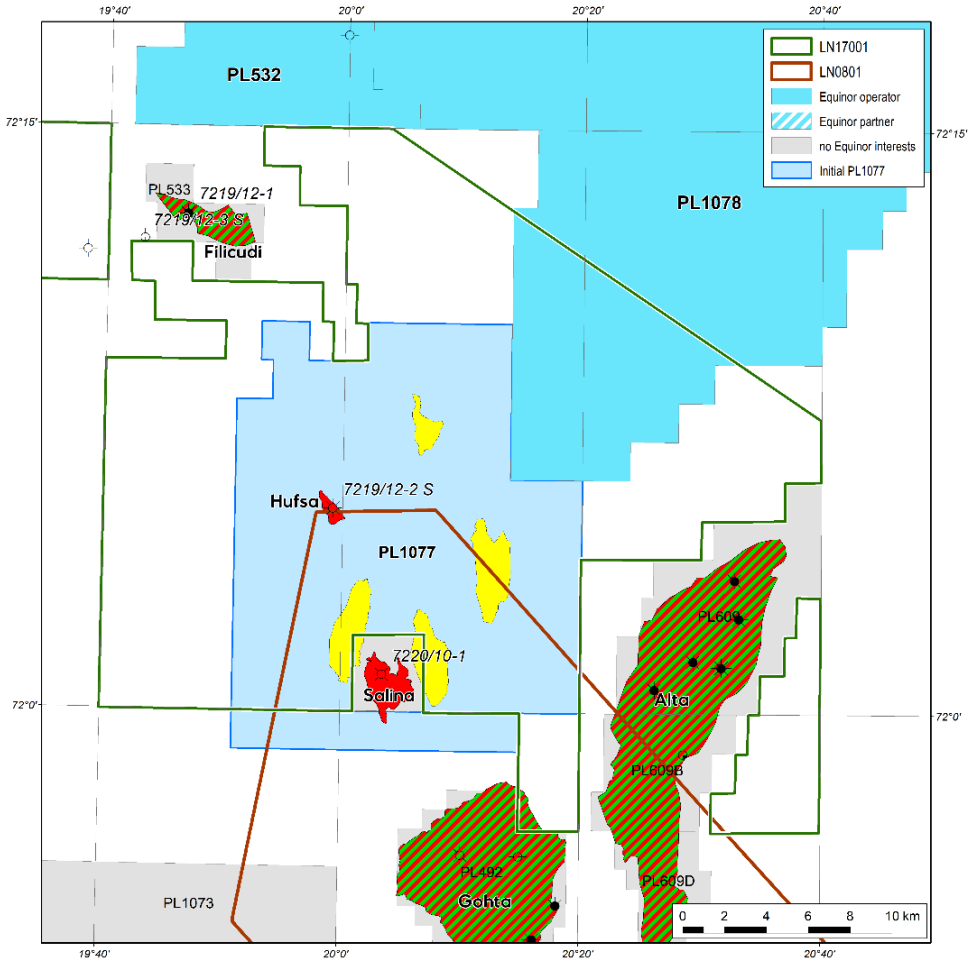

Figure 2. 3D seismic database for PL1077 consisting of the LN0801 and the reprocessed LN17001.

2.2 Well data

The common well database consists of released proximal exploration wells on the same geological trend as the prospects and has been important for the geological understanding and evaluation of PL1077.
Wells 7219/12-1 and 7219/12-1 A (Filicudi) drilled in 2016 discovered oil/gas in Tubåen Formation and these wells were used for fluid properties and better understanding biodegradation. Well 7219/12-3 S (Hurri) drilled in 2018 was used for source rock calibration. Well 7220/10-1 (Salina) drilled in 2012 discovered gas in the Stø- and Kolmule formations. Wells 7219/12-2 S and 7219/12-2 A (Hufsa) drilled in 2017 discovered gas in the Nordmela Formation. The Salina and Hufsa wells were used for well tie, source rock and reservoir calibration and had great impact on the evaluation of the remaining prospectivity and finally the relinquishment decision for PL1077 (Table 2).

Based on the reference wells we believe a functioning petroleum system is present.

Well no	Prospect/discovery name	Reservoir formation	HC phase	Year	Utilization in prospect maturation
7219/12-1	Filicudi	Tubåen	Oil & gas	2016	Fluid properties, biodegradation.
7219/12-1 A					
7219/12-3 S	Hurri			2018	Source rock calibration
7220/10-1	Salina	Kolmule, Stø	Gas	2012	Well tie, source rock calibration, reservoir calibration
7219/12-2 S	Hufsa	Nordmela	Gas	2017	
7219/12-2 A					

Table 2. Overview of well database.

3 Results of geological and geophysical studies

The understanding of the remaining prospectivity in PL1077 is briefly summarized in the section below.

Source and migration
The late Jurassic Hekkingen Formation source rock is the main source for hydrocarbons in the PL1077 area. The source rock is of very good quality. On the Polhem Sub-Platform, at the location of the prospects, the Hekkingen Formation is immature at maximum burial with respect to oil generation. In the western part of the licence, within the Ringvassøy-Loppa Fault complex, the source rock is early- to late oil mature at maximum burial but is rapidly burned out towards the Tromsø Basin. The fault blocks are steeper in this area and progress faster into the deeper area where Hekkingen source rock is burned out.

The prospects are in favourable positions for migration, but there is limited source rock presence within the drainage area and the cumulative expelled hydrocarbon volumes are greatly reduced.

Reservoir quality

The middle Jurassic Stø Formation, constituting the main reservoir within the Realgrunnen Subgroup, has been the main target for many of the wells in the vicinity of PL1077. Well 7219/12-2 A (Hufsa) penetrated 150 m of Stø Formation and had good reservoir development in the well position. Well 7220/10-1 (Salina) found clean, 132 m thick reservoir sandstones with very good quality in the Stø Formation. Within the prospects of PL1077 the Stø Formation is possibly at least 135 m thick and believed to have at least moderate to good reservoir quality.

In relation to the PL1077, there is a trend of biodegradation and heavy oil. Well 7219/12-1 A (Filicudi) is heavily biodegraded and well 7220/10-1 (Salina) show week indications of biodegradation. This gives the prospects a hydrocarbon phase risk.

The Snadd Formation of Late to Middle Triassic age shows reservoir potential in two intervals within the PL1077 area: the Norian marginal marine sands and the Carnian fluvial channels of the late Snadd Formation. The Norian Snadd segment is generally dominated by two laterally continuous marginal marine sands which were transgressed during the Early Norian. The formation shows complex and faulted segments, and the reservoir quality is moderate with maximum burial >3000 m in reference wells. The identified intra Snadd Carnian fluvial channels has a thickness of <50 m. The channels display two distinct intervals and significant fluvial channel morphologies (upper- and lower Carnian sands). The upper Carnian sands has limited channel development in the area. The lower Carnian channel sands are clearly visible on the RMS amplitude response but are heavily segmented. The porosity is moderate, but the permeability is expected to be poor which negatively impacts the producibility. The burial depth, low volume potential, fault segmentation and the limited extent inside the license hampers these prospects and results in a high-risk picture. The Snadd Formation has not been a driver for a separate well.

The deeper stratigraphy is regarded too deep to be of interest as reservoir potential is limited. The Gipsdalen carbonates have likely experienced a maximum burial of >4700 m (180°C) and have been exposed to extensive diagenesis due to high temperatures.

Trap and seal

The remaining prospectivity in PL1077 is related to the Middle Jurassic Stø Formation reservoir within the Realgrunnen Subgroup. The top seal for the remaining prospects is mainly provided by the Torsk Formation. Shallow gas anomalies have been mapped out in the overburden above the prospects fault planes. Well 7220/10-1 (Salina) proved sandy Kolmule Formation with reservoir properties. The Kolmule Formation is draping on to the largest prospect, Osiris, and hydrocarbons have possibly migrated out of the structure. The Manti prospect has Stø Formation juxtaposed against the Kolmule Formation and creates a risk of hydrocarbons spilling out of the structure. The Scipio prospect is fault dependant and Stø Formation is juxtaposed against the Snadd Formation. The Sevier prospect has a smaller 4-way closure but is dependant of fault seal for a deeper filling. The Stø Formation in Sevier is juxtaposed against the Nordmela Formation. In general, all remaining prospects depend on faults to be sealing and the main risk for all prospects is related to trap seal.

Geophysical studies

An AVO workflow was preformed using input from LN17001 angle stacks, and litho- and fluid cubes were generated. The fluid cube 10deg rotation was made to enhance fluids in Early to Middle Jurassic. Litho-cube -60deg rotation was made to image the formations within the Realgrunnen Subgroup. Hydrocarbons are proven to be visible on seismic in the Jurassic reservoirs, and AVO workflow and DFI analyses have concluded the lack of AVO response and no DFI support for larger hydrocarbon columns in the prospects within PL1077.

4 Prospect update report

The prospects from APA 2019 have been updated (Figure 3), and within the blocks 7219/12 and 7220/10, four prospects at Realgrunnen level have been defined and resource assessed (Table 3, Figure 3).

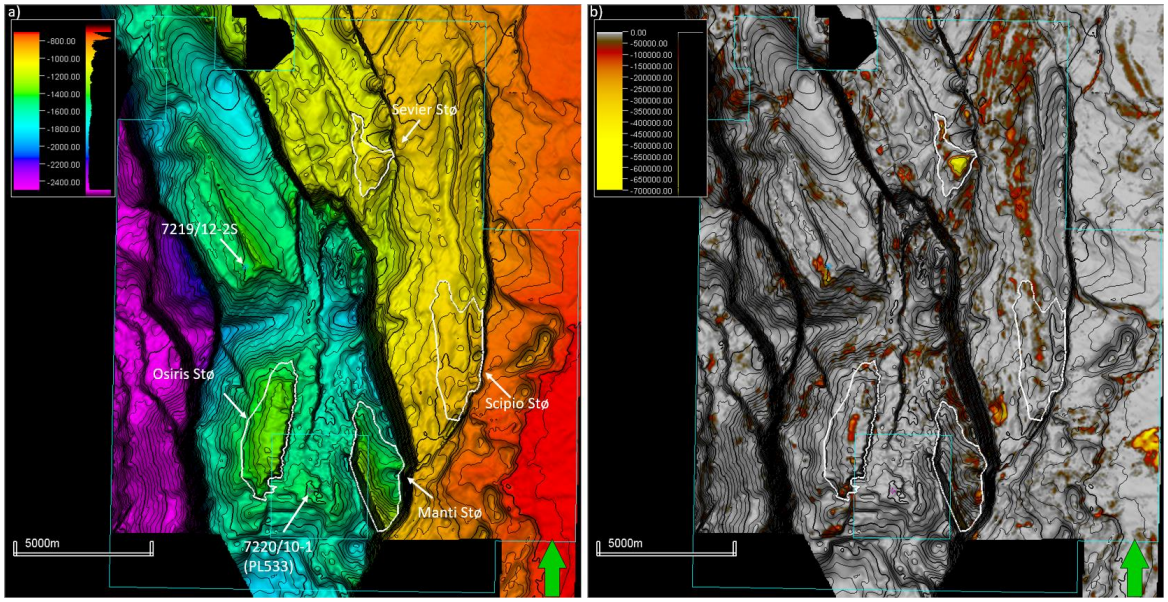

Figure 3 a) Structural depth map of Top Realgrunnen Subgroup. White prospect outlines are indicated for the Osiris, Manti, Scipio and Sevier at Top Stø Formation b) Amplitude extraction from fluid cube -10deg sum of negative amplitude (0 ms up and 10ms down).

Prospect	Litho/Chrono-stratigraphic unit	Depth at apex [m]	HC phase	In-place resources [MSm³/GSm³]			Recoverable resources [MSm³/GSm³]			Pg	Poil	Pgas
				P90	Mean	P10	P90	Mean	P10			
Osiris	Stø Fm/Middle Jurassic	1330	Oil	15.2	49.9	79.9	6.6	22.4	36.3	0.038	0.019	
			Gas	2.6	9.1	14.9	1.52	5.44	9.02			0.016
Manti	Stø Fm/Middle Jurassic	1160	Oil	2.16	26.30	60.03	0.98	11.86	27.25	0.055	0.011	
			Gas	0.294	4.11	10.0	0.178	2.47	6.09			0.036
Scipio	Stø Fm/Middle Jurassic	899	Oil	5.12	10.8	18.4	2.31	4.88	8.33	0.048	0.010	
			Gas	0.658	1.35	2.21	0.377	0.811	1.33			0.031
Sevier	Stø Fm/Middle Jurassic	1009	Oil	1.5	3.14	6.05	0.669	1.41	2.69	0.664	0.062	
			Gas	0.192	0.398	0.679	0.112	0.239	0.409			0.483

Table 3. Overview of resource potential within PL1077, main phases in pure oil- and gas- cases are stated.

Due to the negative results of the geological-, geochemical- and the AVO analysis, the remaining prospectivity is limited to the Lower-Middle Jurassic Realgrunnen Subgroup/ Stø Formation.

The Lower-Middle Jurassic Realgrunnen prospects are shown in Figure 4, Figure 5, Figure 6, and Figure 7. The prospects are defined within rotated fault blocks and mainly shows lack of amplitude anomalies.
Risk is also related to hydrocarbon phase, as the nearby well 7219/12-1 (Filicudi) proved biodegraded oil.

The Osiris prospect (Figure 4) has the largest oil potential (Table 3). The prospect is a 3-way closure, bounded by a fault towards the east, situated in the same block as well 7219/12-2 A (Hufsa) and up-dip of well 7220/10-1 (Salina). The Stø Formation reservoir juxtaposes the sandy Kolmule Formation across the bounding fault. Well 7220/10-1 proved the presence of Kolmule Formation with reservoir properties. This provides high trap seal risk due to leakage to the sandy syn-rift or overlaying formations. Due to the lack of amplitude support, Osiris has been given a DHI downgrade.

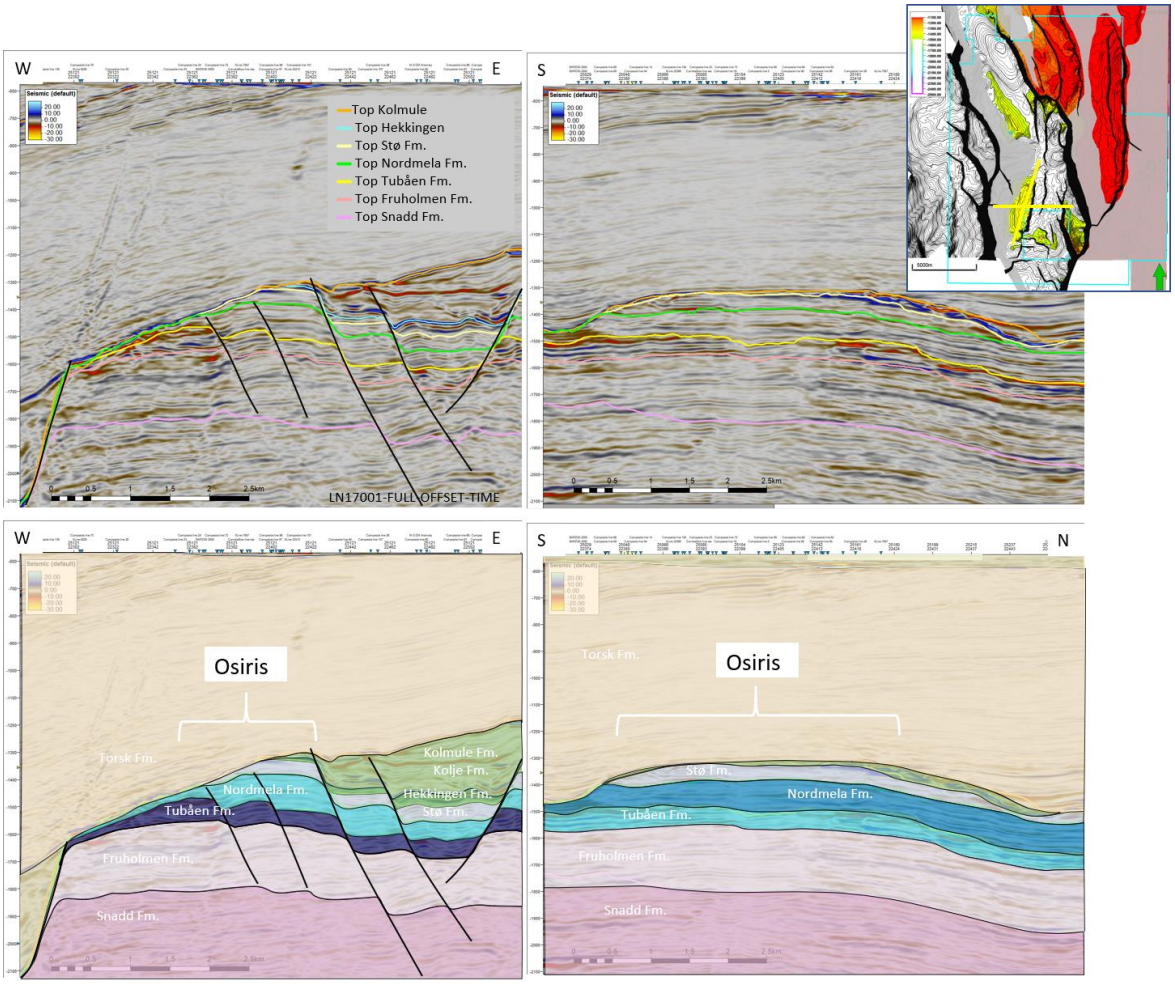

Figure 4) Seismic section showing LN17001 E-W and N-S arbitrary lines across the Osiris prospect.

The Manti prospect is fault dependant, situated up-dip of the Salina gas discovery (Figure 5). Towards Salina to the west, the Stø Formation juxtaposes the sandy Kolmule Formation and towards the south-east Stø Formation juxtaposes the Snadd Formation. The key risk is trap seal due to high risk of leakage across multiple faults. Lack of amplitude support gives a DHI downgrade.

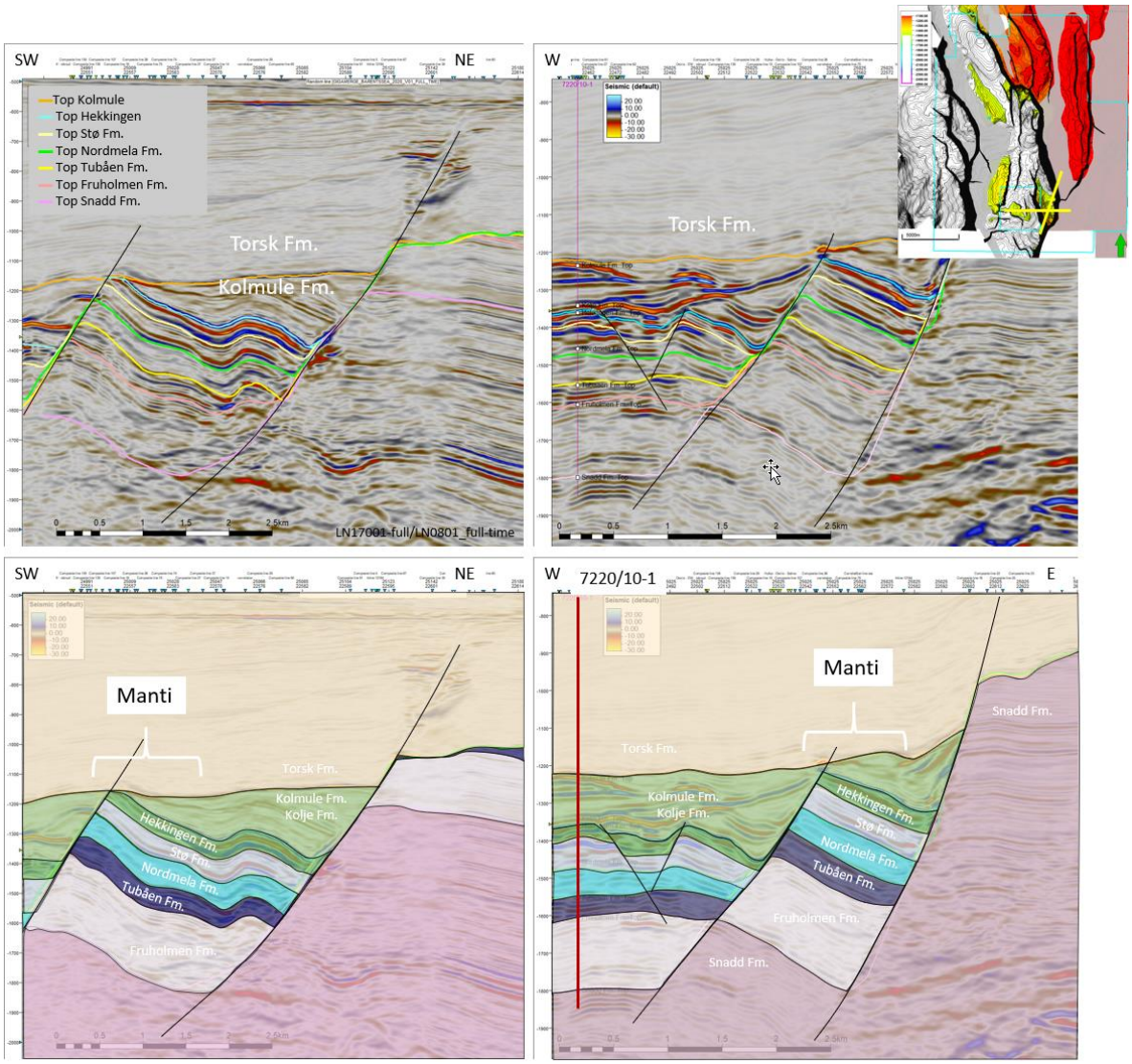

Figure 5) Seismic section showing LN17001/LN0801 arbitrary lines across the Manti prospect.

The Scipio prospect (Figure 6) is a heavily eroded fault block, and the Early Jurassic Realgrunnen Subgroup is eroded on top of the structure. Realgrunnen is juxtaposed against the Snadd Formation across the bounding fault towards east and the trap is dependent on this fault to be sealing. The lack of amplitude support gives the prospect a DHI downgrade.

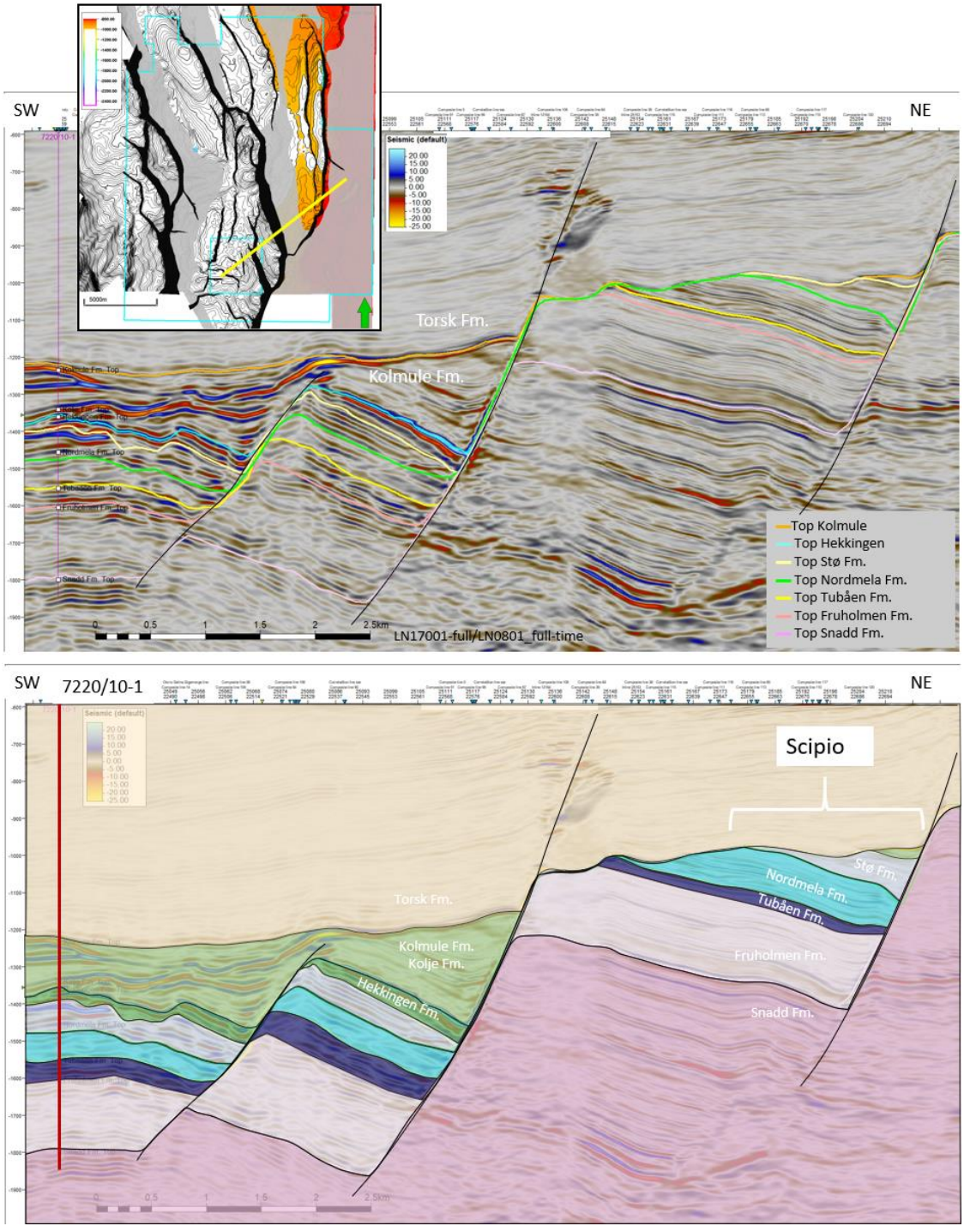

Figure 6) Seismic section showing LN17001/LN0801 arbitrary line across the Scipio prospect.

The Sevier prospect (Figure 7) has a maximum outline dependant on a sealing fault towards the east but has a smaller 4-way closure which fits well with the amplitude anomaly in the Stø Formation (Figure 3b).
The Stø Formation is juxtaposed against the Kolmule/Kolje and Nordmela formations, which creates a risk of fault leakage. The amplitude support gives the prospect a DHI upgrade, but the mean recoverable oil volume is negligible (Table 3).

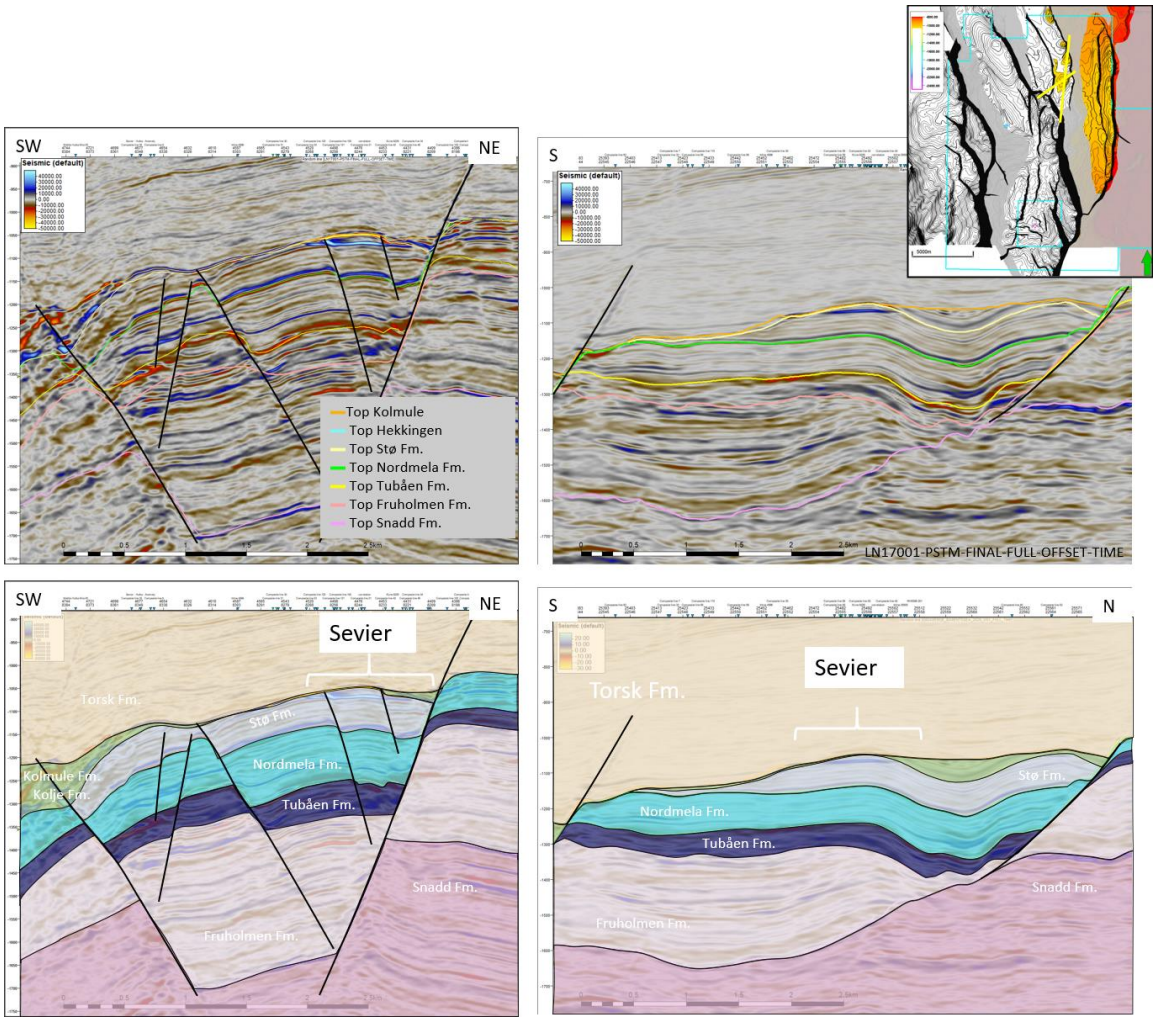

Figure 7) Seismic section showing LN17001/LN0801 arbitrary lines across the Sevier prospect.

The two nearest gas discoveries (7220/10-1 and 7219/12-2S) have amplitude anomalies corresponding with the gas discovery and the aim of the license has been to uplift the remaining prospectivity using AVO workflow on the most resent LN17001 survey.

AVO workflow and DFI analysis has been completed and concludes with no DFI support for significant oil columns on any of the prospects, therefore DFI downgrade has been applied in the prospect risking. Petroleum System Analysis indicates that the prospects are in a favourable location for migration from Hekkingen source rock, but possibly limited oil expulsion due to lack of Hekkingen in the fault planes towards the west. This may explain the dominance of gas in the area and reduces chance for oil.

AVO and PSA work result in very low probabilities for significant oil/gas discoveries.
Overall, the prospects show good volume potential (particularly the Osiris structure), but low probabilities reflect lack of belief in commercial discoveries, and further technical work is unlikely to resolve this.

The Snadd Formation reflects a similar structural terrain as for Top Stø Formation. Hydrocarbon associated amplitude anomalies have not been identified and prospects related to the upper Snadd Formation have not been identified. Carnian fluvial channels of the late Snadd Formation is heavily segmented with limited potential and poor reservoir. These are not considered as valid prospects.

5 Technical evaluation

The oil volume potential of the Realgrunnen prospects was regarded as feasible to be tied back to Johan Castberg located 50 km to the north. Alternatively, a stand-alone solution could be an option assuming a discovery of high enough volumes. An economical evaluation showed that the very low probability of discovery gives a significantly high risked economic volume.

6 Conclusion

The licence partner has unanimously decided to let the license expire when the initial period ended 14.02.2022, due to the limited remaining prospectivity and current lack of a drilling candidate.

References

Equinor (2019). Application Part of blocks 71193, 71201, 721912 and 722010 - APA2019, Norwegian continental shelf.

Appendices

1. NPD Table 5 Prospect data status-report-surrender - English - OD - Manti Stø
2. NPD Table 5 Prospect data status-report-surrender - English - OD - Osiris Stø
3. NPD Table 5 Prospect data status-report-surrender - English - OD - Scipio Stø
4. NPD Table 5 Prospect data status-report-surrender - English - OD - Sevier Stø