



## **PL 949 – Licence status report**

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## Summary

PL949 (Equinor Energy AS Op/50%, Norske Shell AS/30%, Petoro AS/20%) was awarded in March 2018 (APA 2017) with a decision on 3D seismic or DoD to be taken within March 2020. As a part of the work program, reprocessing of 2D and 3D seismic (EQ18M13) has been done within the licence. The main prospect in the licence is the Makrell prospect, which is mapped out on the new reprocessed 3D seismic. It shows a robust 4-way dip closure, both in time and depth, at Near Top Paleocene level. Key risk of the prospect is reservoir presence and quality, because of the distal location to the expected sediment source from the East. Other risks to the prospect are trap seal and source rock maturation. A quantitative geophysical analysis of EQ18M13 is performed, resulting in a downgrade in DHI risking. Cretaceous prospectivity has been considered in the licence. PL949 is expected to be located distal to Cretaceous reservoir distribution systems from the East, and hence, low quality reservoir is expected. A scanning of the Cretaceous section is done on EQ18M13 and no amplitude anomalies are observed. Low Pg and relatively low volumes in the Palaeocene section and no obvious prospectivity in Cretaceous are the basis for the licence decision to relinquish PL949 at the milestone in March 2020. Because the relatively poor seismic data quality of the reprocessed data, especially in the Cretaceous section, is believed to be generated by the complex geology in the area, it is not expected that acquisition of a new 3D seismic survey will improve the basis for the decision. Therefore, the licence will not decide to acquire new 3D seismic as a part of the work program.

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## 1 Key licence history

**Licence:** PL949

**Awarded:** 02.03.2018

**Licence blocks:** 6608/2 & 6608/3

**Licence period:** Expire 02.03.2025 (3D seismic or DOD 02.03.2020)

**Licence group:**

Equinor Energy AS	50% (Operator)
Norske Shell AS	30%
Petoro AS	20%

**Licence area:** 814.986 km<sup>2</sup> (Figure 1-1)

**Work program:**

Reprocessing of 2D and/or 3D seismic (fulfilled)  
 3D seismic acquisition or DoD, deadline March 2<sup>nd</sup>. 2020.

**Meetings held:**

23.04.2018	EC/MC startup meeting (1)
12.06.2018	EC work meeting, Procurement evaluation
31.10.2018	EC work meeting, Reprocessing review at Western Geco's premises
27.11.2018	EC/MC meeting (2)
30.10.2019	EC/MC meeting (3)

**Work performed:**

2018:	Licence start-up
2018/2019:	Reprocessing of 3D seismic and various 2D seismic lines (by Western Geco)
2019:	Makrell prospect evaluation / seismic interpretation / quantitative geophysical evaluation / screening for Cretaceous prospectivity
2020:	Decision made not to drill within the licence

**Reason for drop:**

The evaluated Makrell prospect in PL949 is, due to high risk, not regarded as a drilling candidate. In addition, deeper Cretaceous prospectivity in the licence has been screened and is regarded as being not valuable. The benefits of acquiring new 3D seismic as a part of the work programme have been evaluated. The conclusion from this has been that it is highly unlikely that a new 3D survey would result in a different view on the prospectivity.

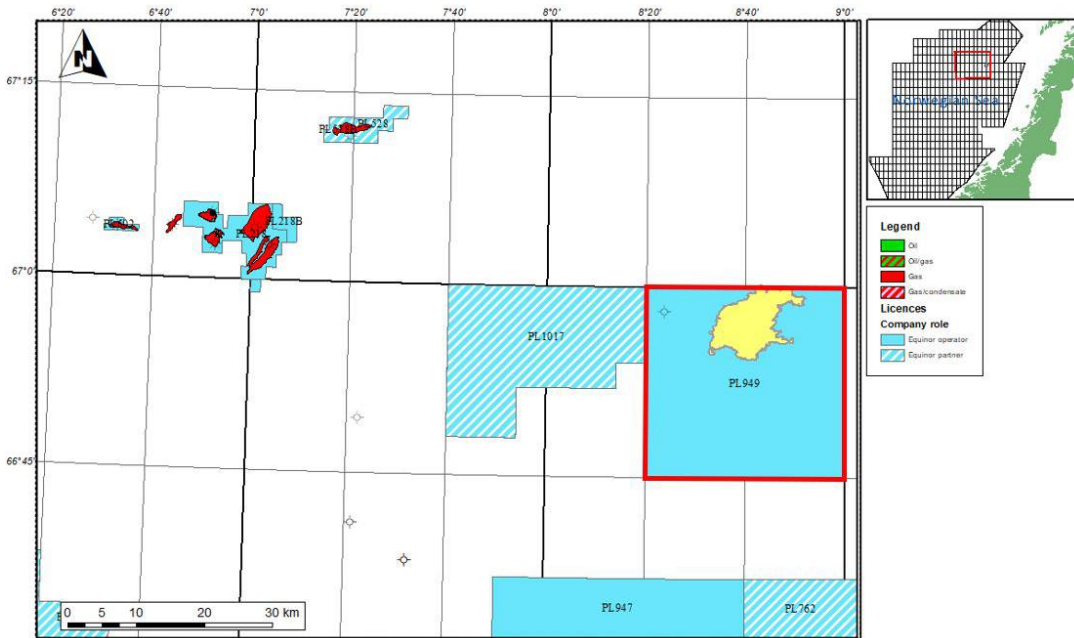


Figure 1-1 PL949 location (red outline) with main prospect Makrell outline.

## 2 Database overviews

### 2.1 Seismic data

The EQ18M13 3D PSDM seismic survey is a merge of RD1202 and RD0601 and was reprocessed for the PL949 licence in 2018/2019. In addition, a number of 2D seismic lines were reprocessed with the scope of mapping out a possible sediment fairway from the East. The location of the seismic data is shown in Figure 2-1 and listed in Table 2-1.

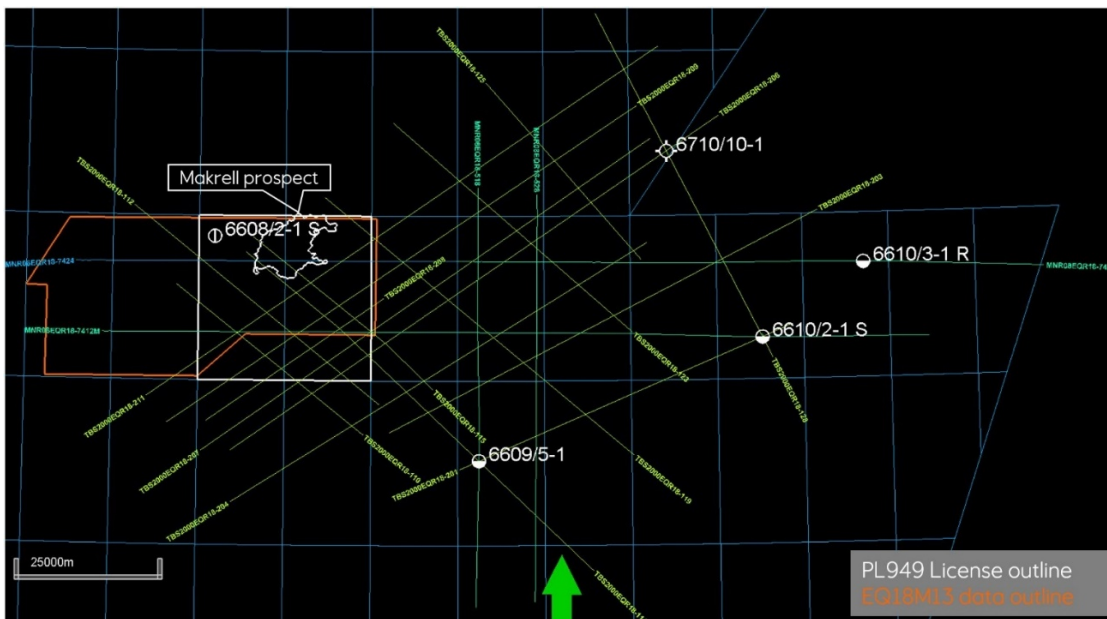


Figure 2-1 Location map of 2D/3D seismic, reprocessed for PL949 and PL949 common database wells.

**Table 2-1 List of 2D/3D seismic in the PL949 common database**

Seismic	Type	Stacks
EQ18M13	3D	All stacks (time and depth)
TBS2000EQR18-110, 112, 114, 115, 119, 123, 125, 128, 201, 203, 204, 206, 207, 208, 209, 211	2D	All stacks (time and depth)
MNRO6EQR18-7424	2D	All stacks (time and depth)
MNRO8EQR18-7424, 7424M, 518, 528	All	All stacks (time and depth)
RD1202	3D	All stacks, Beam and Kirchoff
RDO601R10	3D	Full stack
RDO601	Field data	
MNRO7	2D	All stacks
MNRO8	2D	All stacks
MNR10	2D	All stacks
MNR11	2D	All stacks
N2N3T96	2D	Full stack
NPD-VOERB-86	2D	Full stack
TBS-2000	2D	Full stack

## 2.2 Well data

A list of wells in the common well database for PL949 is listed in Table 2-2 and are shown in Figure 2-1.

**Table 2-2 List of wells in PL949 common well database**

Well	Year	Operator
6608/2-1 S	2013	RWE DEA
6609/5-1	1985	Statoil AS
6610/2-1 S	1996	Statoil AS
6610/3-1, 3-1 R	1993	Statoil AS
6710/10-1	2000	Statoil AS

## 3 Review of geological framework

No geological or geochemical studies have been performed beside evaluation of the prospectivity.

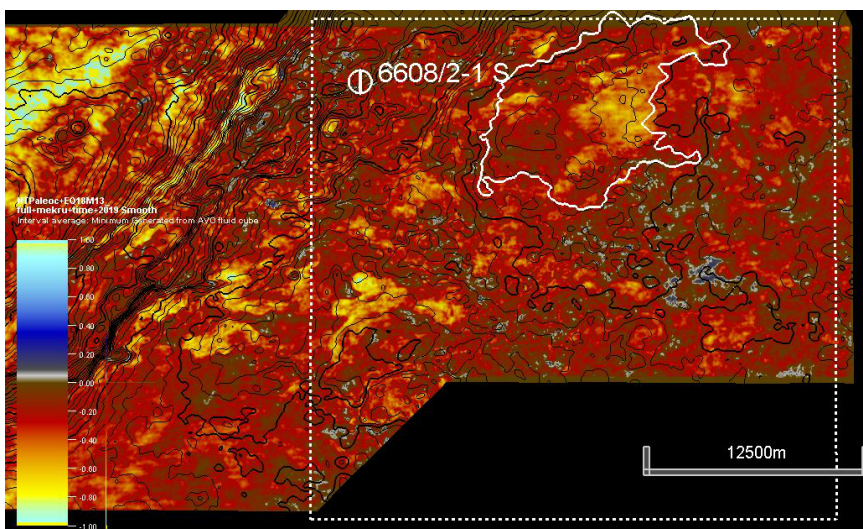
A quantitative geophysical analysis was performed on the EQ18M13 dataset. An AVO anomaly below top reservoir of the Makrell prospect is observed downflank of the prospect apex and is not depth conformant (Figure 4-1). Extractions of the P-impedance and S-impedance indicates lithology changes and plots as AVO class III or IV, which indicates a porous

layer. This could be a tuffaceous claystone, which is also found in the surrounding wells in the respective level. The AVO screening shows that there is no clear evidence for sand in Makrell and no indication of any HC's or depth conformant amplitude response. Hence, a DFI downgrade is applied to the a priori geological chance of success, and the final Pg goes from 13 % to 8 %.

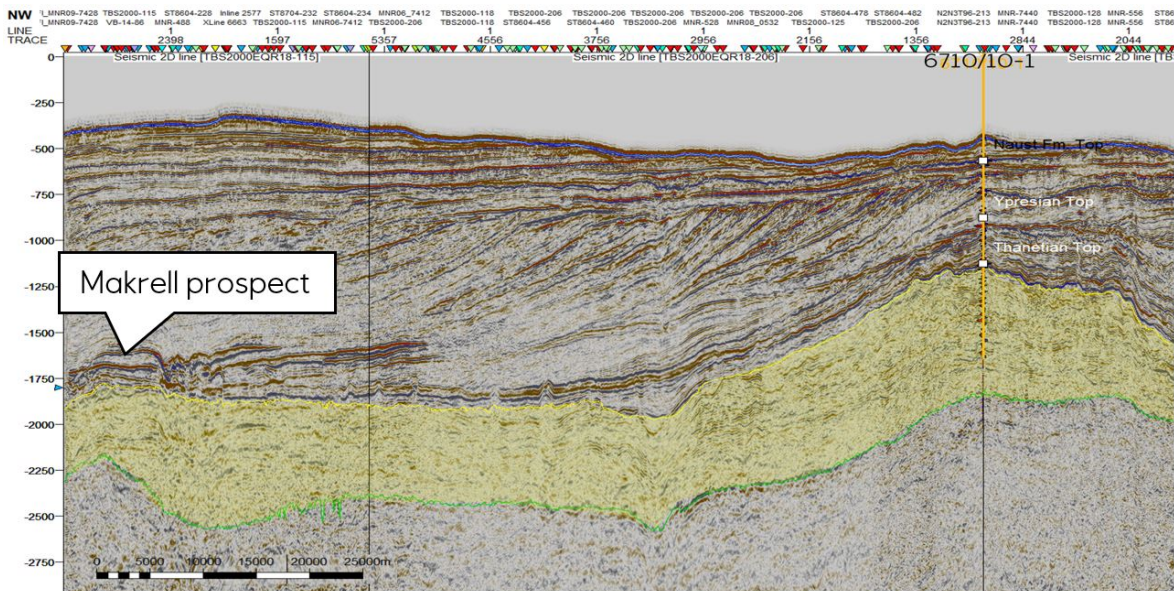
## 4 Prospectivity

### Paleocene:

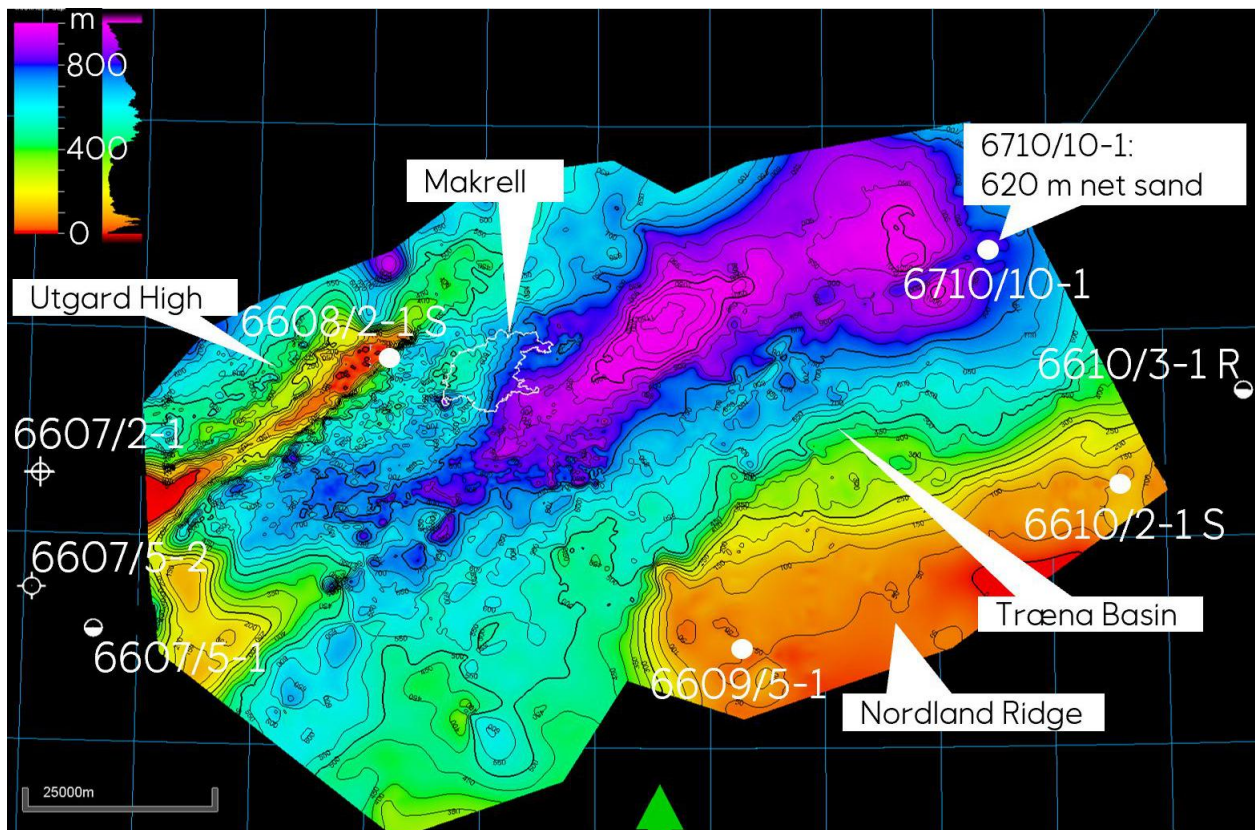
The PL949 area is located on the eastern flank of the Utgard High, approximately 60 km southeast of the Aasta Hansteen Field. The focus in the licence has been the Palaeocene Makrell prospect, which is evaluated on the reprocessed 3D seismic cube, EQ18M13. Approximately 60 km northeast of Makrell, the 6710/10-1 well has proven more than 600 m net sand, representing a Palaeocene deep-marine turbiditic fan, extending towards the Makrell prospect. The seismic tie of the Paleocene section from 6710/10-1 to Makrell is challenging due to long distance and varying seismic quality (Figure 4-2). Hence, some uncertainty is related to the Paleocene pick in the Makrell area. The proven Paleocene sand in 6710/10-1 has been the driver for the Makrell APA application. Mapping of the Paleocene fan has been done on reprocessed 2D seismic lines, showing a very distal and off-axial location of Makrell (Figure 4-3). In addition, the prospect is located on the flanks of the active Utgard High. A significant risk on reservoir is therefore applied to the prospect evaluation, especially the reservoir quality. It is expected that mostly fine-grained material will be deposited in such a setting, and hence, N/G in Makrell is relatively low (Table 4-1). The Makrell prospect is defined as a 4-way dip closure as shown in Figure 4-4, a. Some risk is ascribed to the trap seal due to possible leakage from small scale faulting, in addition to potential thief sands in the top seal Brygge Fm. A rugose unconformity and a chaotic seismic signature above the prospect (Figure 4-4, b) is described as mass transport deposits, but an alternative interpretation can be injectites, which would enhance the seal risk even further. The injectites are not investigated and are therefore not a part of the present risk picture. The main risk of the prospect is, however, related to the presence and quality of reservoir. A thorough AVO study shows no indications of neither sand nor hydrocarbons within Makrell, as explained in chapter 3.



**Figure 4-1 Top Paleocene (top reservoir) Interval minimum AVO map, 0- -50 ms, showing a non-depth conformant anomaly east of the prospect apex, interpreted as being tuffaceous claystone.**



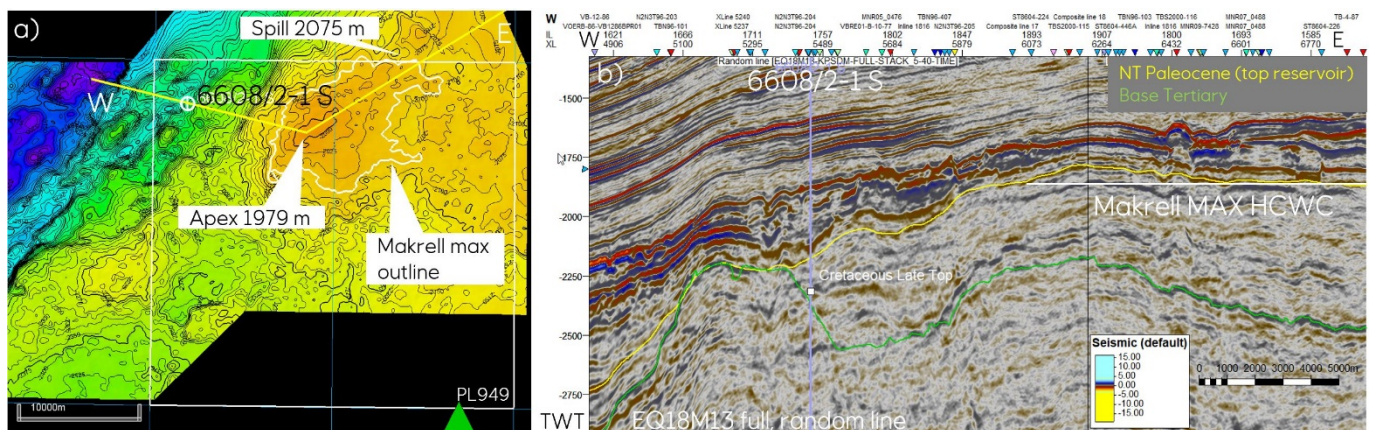
**Figure 4-2** 2D seismic line showing the tie between the 6710/10-1 well and Makrell. The tie of the Paleocene section (marked in yellow) is challenging due to long distance and varying seismic quality.



**Figure 4-3** Paleocene thickness map. The Paleocene deep marine turbiditic fan, proven by >600 m net sand in 6710/10-1, is mapped out on reprocessed 2D seismic lines. The Makrell prospect is located distal and off-axial to the fan and on the flanks of the active Utgard High.

**Table 4-1 Makrell prospect parameters for volume input.**

Parameters reservoir/fluid	Min	Mean	Max
Reservoir thickness (m)	50	90	150
N/G	0.2	0.3	0.5
Porosity	0.15	0.2	0.25
Oil saturation	0.5	0.6	0.7
Gas saturation	0.65	0.7	0.8
Wet gas shrinkage factor	1	1	1
GOR [Sm <sup>3</sup> /m <sup>3</sup> ]	40	60	80
Shrinkage factor oil 1/Bo [Sm <sup>3</sup> /m <sup>3</sup> ]	0.73	0.83	0.93
Expansion factor gas (1/Bg) [Sm <sup>3</sup> /m <sup>3</sup> ]	200	215	230
Condensate yield [Sm <sup>3</sup> /10 <sup>6</sup> Sm <sup>3</sup> ]	14	17	20
Recovery factor non. assoc. gas	0.6	0.7	0.75
Recovery factor condensate	0.5	0.57	0.65

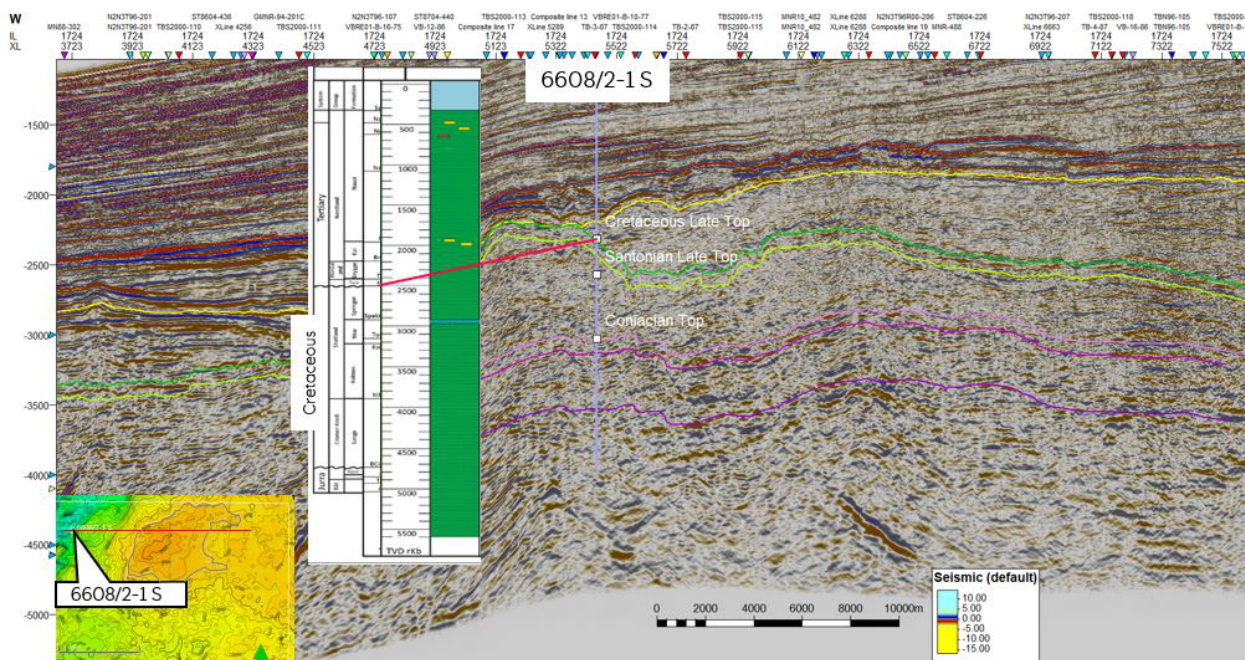


**Figure 4-4 a) Makrell top reservoir depth map with the HCWC max filling contour. b) Seismic time line through the 6608/2-1 S well and the Makrell prospect. Chaotic seismic signature is observed above the prospect, at near base Naust.**

**Other prospectivity, Cretaceous:**

The 6608/2-1 S well has an almost complete Cretaceous section of shales, deposited at the crest of the Utgard High, which has been a submarine high throughout time. The well location on the Utgard High excludes the possibility for Cretaceous sand deposition from the West into the PL949 area. Wells in the area indicate sand systems coming from the East. Sedimentation from the East to the PL949 area must pass the vast Træna Basin, which has been a large depocenter since Jurassic times. It is possible that extensive sand systems have reached the PL949 area, but it is expected that these sands will be very distal, and hence, low reservoir quality. In addition, the temperature gradient in

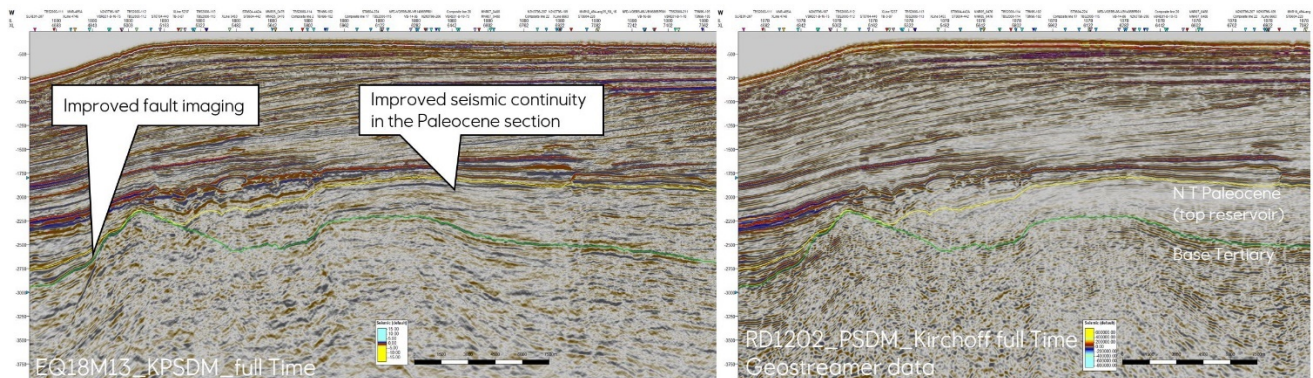
6608/2-1 S shows that only Upper Cretaceous reservoir will be above the threshold for a decent reservoir, due to quartz cementation. Various levels through the Cretaceous section has been scanned through on EQ18M13. The newly reprocessed seismic data set has poor data quality in the Cretaceous section and interpretation is difficult. Shifting of the Top Springar horizon is done to various levels (Figure 4-5) and no amplitude anomalies are observed. The facts that the 6608/2-1 S well has no sand in Cretaceous and that possible sands from the east will be distal with low reservoir quality, support the observed missing amplitudes within the licence. Based on that, the Cretaceous play is not considered interesting in PL949.



**Figure 4-5 – Seismic section showing the Cretaceous data quality. The dark green horizon, Top Springar, has been time shifted and scanned for possible amplitudes.**

## 5 Work program

The focus of the reprocessed EQ18M13 was to improve the Paleocene section This has been achieved, along with improvements of fault imaging (**Figure 5-1**). Further improvement of data quality in the Cretaceous section is important for further prospect evaluation. In the PL949 work program, a decision on acquisition of a new 3D seismic survey had to be taken. The reprocessed EQ18M13 is a merge of two 3D data sets, one geostreamer dataset from 2012 and one conventional streamer data set from 2006. The 2012 data set is considered acquired with reasonable technologies, according to present day standard. Comparing the reprocessed data across the merge of the two old data sets, no significant differences are observed. The multiples and the noise, which is increasing downwards in the Cretaceous section, is believed to be generated by the geology in the area, such as complexities in the overburden and the rugose unconformity at near base Naust (**Figure 4-4, b**). It is likely that a new seismic survey will have similar challenges and it was therefore decided not to acquire new seismic in the licence.



**Figure 5-1 Data quality comparison between the reprocessed PSDM EQ18M13 and the RD1202 PSDM, which is the base of the reprocessing.**

## 6 Technical evaluation

The Makrell prospect has been evaluated to hold a too high risk, compared to the relatively low volumes (Table 6-1), in order to make a positive drilling decision. Therefore, no technical evaluation has been performed.

**Table 6-1 Volume potential Makrell.**

Prospect	In-place resources P90-Mean-P10 [MSm3 OE]	Rec. resources P90-Mean-P10 [MSm3 OE]	Pg	HC phase split (gas/oil %)
Makrell (Tang Fm)	3.0-10.6-21.6	2.1-6.3-12.5	8 %	90/10

## 7 Conclusion

Seismic reprocessing as a part of the work programme, has been fulfilled. The partners agreed that the Makrell prospect did not qualify as an exploration drilling candidate based on the technical evaluation done. Based on that, the licence has been dropped at the DoD milestone in March 2020.