PL 1058 – Licence status report

Summary

PL1058 is located on the Frøya High in the Norwegian Sea, approximately 10 km south of the Njord field. The area was awarded in the TFO2019 round with Equinor Energy as operator (60%) and Chrysaor Norge (40%) as partner. PL1058 holds basement, Triassic and potentially upper Jurassic structures. Tree wells have tested the prospectivety in the area previously, two wells on the Frøya high, 6407/10-3 and 6407/10-4, while the last well 6307/1-1 drilled into the Triassic stratigraphy in the Froan basin east of PL1058. The Frøya High wells both had limited shows in the upper Triassic strata beneath the BCU, the shows are not of the same age in the two wells. The 6307/1-1 did not contain shows but proved middle Triassic volcanic activity.

In the licence period the basement, upper Jurassic and Triassic play were evaluated. After considering the leads and prospects a well decision with a Triassic target was made in February 2022. In May 2023 an early pilot 6307/1-U-1 was drilled to de-risk shallow hazards, the main well 6307/1-2 JDE was drilled in August/ September the same year. The primary well objective was to test Triassic reservoir potential of Carnian to late Ladinian age. The well did not encounter any reservoir potential in the primary target and the deeper second target showed poor to limited potential. Three thin beds of volcanic rocks were encountered, no shows of hydrocarbons in siliciclastic rocks were observed. The JDE well was drilled with a substantial dry well acquisition programme, to provide improved knowledge of the Triassic play in the Norwegian Sea. A total of 27m of core was acquired and 57 SWC plugs successfully retrieved.

With no other prospects of significant potential in the area, the licence is seeking relinquishment.

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1 Licence history

PL1058 is located on the Frøya High in the Norwegian Sea, approximately 10 km south of the Njord field, see figure 1.1. The area was awarded in the TFO2019 round with Equinor Energy as operator (60%) and Chrysaor Norge (40%) as partner. PL1058 holds basement, Triassic and potentially upper Jurassic structures. Three wells have tested the prospectivety in the area previously, two wells on the Frøya high, 6407/10-3 and 6407/10-3, while the last well 6307/1-1 was testing the analogue stratigraphy in the Froan basin east of PL1058. The Frøya High wells both had limited shows in the upper Triassic strata beneath the BCU, while the 6307/1-1 did not contain shows, but proved strong volcanic activity in Triassic time. The stratigraphy of the Triassic shows is not of the same age in the two wells 6407/10-3 and 6407/10-4.

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1.1 Licence information

Licence:	PL1058	
Awarded:	14.02.2020	
License period:	Expires 14.02.2027 Initial period: 7 years	
License group:	Equinor Energy AS Harbour Energy AS	60% (Operator) 40%
License area:	274 km^2	

Work programme:

Study of geology and geophysics	Approved
Re-processing of seismic data	Approved
Decision to drill (JDE)	14.02.2022
Drill exploration well	
Initial BOK by 14.02.2024	-Applied and approved 6-months extension due to post well analysis
(BOK) Decision to concretize	14.08.2024
(BOV) Decision to continue	14.08.2024

Work performed:

2020:	Licence start-up. G&G studies

2021: Re-processing, G&G studies & prospect evaluation
2022: Well planning
2023: Drilling exploration well
2024: Post well evaluation

1.2 Licence Meetings held:

Date	Licence Meeting
16.04.2020	EC-MC No. 1
22.10.2020	EC-MC Meeting No. 2
07.05.2021	EC Work Meeting No. 1
10.06.2021	EC-MC Meeting No.3
03.09.2021	EC Work Meeting No.2
22.09.2021	CDB Teams Meeting
19.10.2021	EC Work Meeting No.3
17.11.2021	EC-MC Meeting No.4
13.09.2022	EC Work meeting No.4 - Wellplanning 6307 1 -2 JDE
31.10.2022	EC Work Meeting No.5 - Wellplanning status
24.11.2022	EC MC Meeting No.5
09.12.2022	EC Work Meeting N0.6 - Wellplanning DAMS
10.02.2023	EC informational meeting Well planning status
05.05.2023	EC Work Meeting No.7 - Pilot well summary
16.05.2023	EC Work Meeting No.8 - Well planning summary
30.08.2023	EC Work Meeting No.9 - Operations summary
20.09.2023	EC Short meeting canned samples interval
04.10.2023	EC Short status meeting- Drilling operations
20.10.2023	EC Post well summary preliminary
30.10.2023	EC Work Meeting No.10 - Coring analysis program
30.11.2023	EC-MC - No.6
15.03.2024	EC Work Meeting No.11 - Core viewing
07.11.2024	EC No.12 - PL1058 Licence wrap-up

1.3 Reason for surrender:

The conclusions of the technical evaluation of the dry 6307/1-2 well, show that the remaining prospectivity in the license does not justify another exploration well within the licenced area. Volumes are evaluated to be small, and have a high reservoir risk. As a result, it was unanimously decided to surrender the licence.

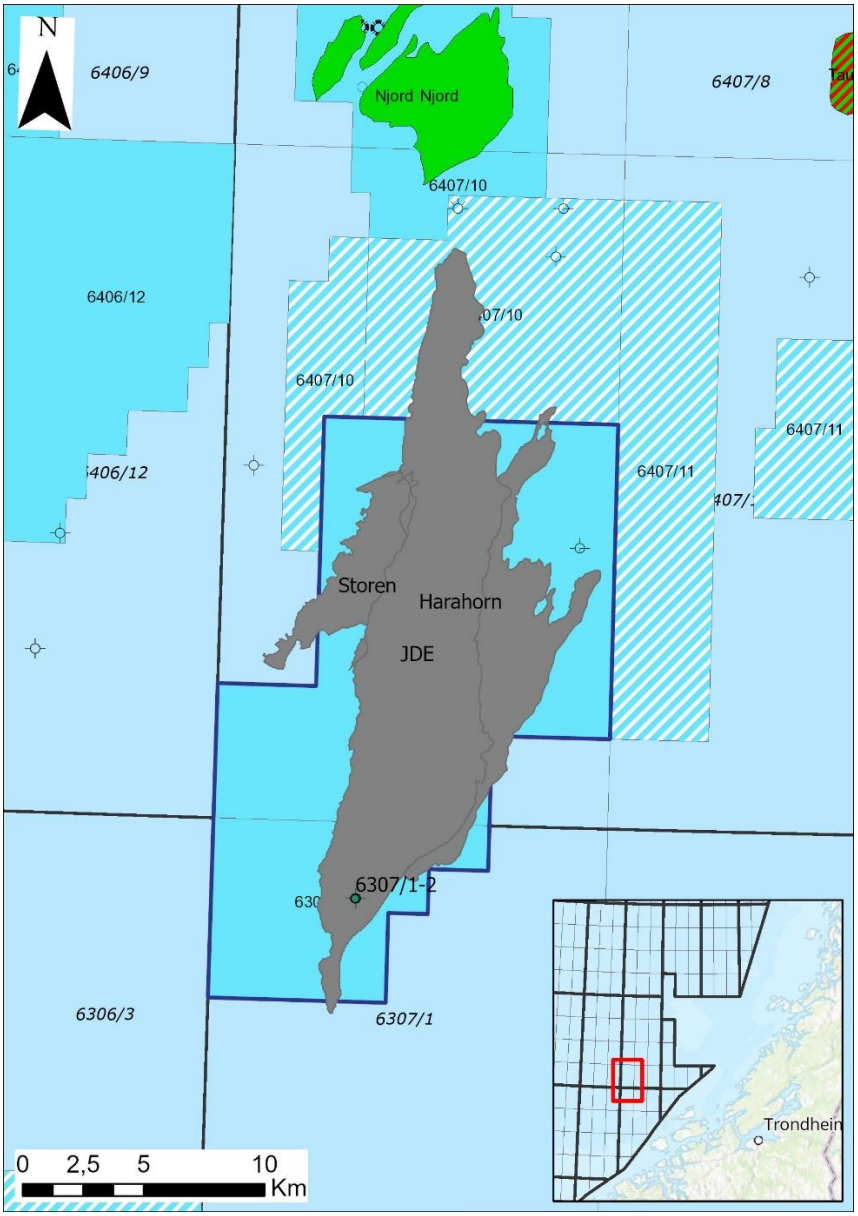

Figure 1-1: Location map of PL1058 with licence prospects & leads, fields and exploration wells.

2 Database overviews

2.1 Seismic data

The PGS18M05/ PGS17M05 datasets were used as a reference for the evaluation and preparation of the re-processing of the PGS14005 survey. The evaluation of the prospectivety of PL1058 was done on the re-processed PGS14005EQRZ21 dataset. Datasets evaluated used in the technical work performed can be found in table 1. Outline of common seismic database is documented in figure 2-1.

Table 1: List of seismic surveys used in the common licence database

Seismic Survey	Vintages	2D/3D	Acquisition/ reprocessed	Qual.	NPDID
PGS18M05	Full, angle stacks,raw,vels	3D	2014/2018	Very Good	8054
PGS17M05	Full, angle stacks,raw,vels	3D	2014/2017	Very Good	8054,8457
PGS14005	Full, angle stacks	3D	2014	Very Good	8054
PGS14005	Shots, P-up	3D	2014	Very Good	8054
PGS14005EQRZ21	Full, angle stacks, CMP gathers, de-multiple shots	3D	2014/2021	Very Good	8054
PGS14005	Full stack	3D	2014	Good	8054

2.2 Well data

Table 2: List of wells used in the common licence database

Well name	Year	Operator	Licence	Result	BH Formation	Purpose	NPDID
16/1-12	2009	Lundin Norway AS	PL338	Oil	Basement	Stratigraphy	6166
6306/6-1	1994	Statoil Petroleum AS	PL198	Dry	Basement	Stratigraphy, pressure, PVT	2384
6306/6-2	2009	Det norske oljeselskap	PL321	Dry (weak shows)	Basement	Stratigraphy, shows	6143
6306/10-1	1990	A/S Norske Shell	PL155	Oil/gas	Basement	Stratigraphy, pressure, PVT	1551
6407/7-2	1987	Norsk Hydro Produksjon AS	PL107	Oil/gas	Red Beds	Stratigraphy, pressure, PVT	1017
6407/9-1	1984	A/S Norske Shell	PL093	Oil	Red Beds	Stratigraphy, pressure	133
6407/10-2	1990	Norsk Hydro Produksjon AS	PL132	Shows	Tilje Fm.	Pressure, shows	1497
6407/10-3	1992	Norsk Hydro Produksjon AS	PL132	Shows	Basement	Stratigraphy, pressure, shows	1927
6407/10-4	2016	Lundin Norway AS	PL700B	Shows	Basement	Stratigraphy, pressure, shows	7699
6507/12-2	1983	Saga Petroleum AS	PL289L	Shows	Red Beds	Stratigraphy, pressure, shows	437
6609/7-1	1983	Philips Petroleum Company	PL081	Dry	Basement	Stratigraphy	19
6307/1-1 S	2018	Lundin Norway AS	PL830	Dry	Basement	Stratigraphy, pressure, PVT	8523
6407/7-1 S	1986	Norsk Hydro Produksjon AS	PL107	Oil/gas	Red Beds	Stratigraphy, pressure, PVT	474
6507/6-4 A	2012	E.ON Ruhrgas Norge AS	PL350	DRY	Permian	Stratigraphy	6753
6307/1-2	2023	Equinor AS	PL1058	DRY	Triassic		9885

In table 2 a list of the wells used in the technical work is provided. As the Triassic interval is sparsely sampled in the Norwegian Sea, relevant wells from other basins were included. This was done to improve the understanding of the Triassic interval. Well information of nearby wells guided the velocity model building, well-ties, fluid substitution modelling and basin modelling, PSA work.

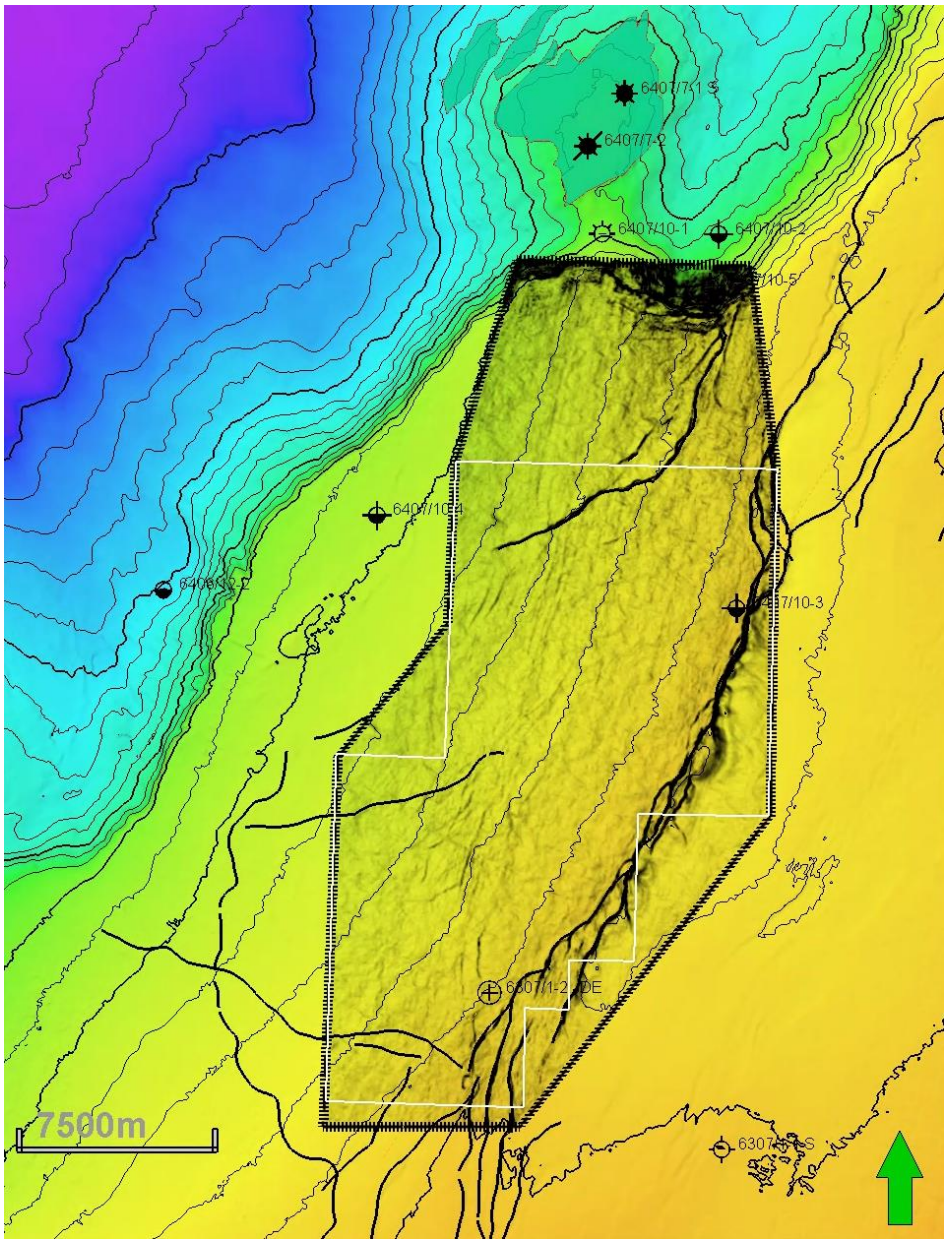

Figure 2-1: Map of BCU with PL1058 outline in white and Common seismic database in dotted black. Re-processed PGS14005EQRZ21 follows the Common database outline.

3 Results of geological and geophysical studies

The following G&G studies were carried out in the licence evaluation

- Seismic re-processing of the PGS14005
- Seismic interpretation and mapping
- Structural restoration of the Frøya High, PL1058 area
- Geophysical observations and AVO analysis
- Prospect evaluation

3.1 Seismic re-processing of PGS14005

Re-processing of the PGS14005 broadband dataset was done from the P-up shot gathers provided by PGS. It was necessary to go back to the earliest processing step sue to issues with notches in the spectrum. Remnant multiple energy, resolution of the Spekk/Jurassic/Triassic interfaces were also targeted in the objectives, and this required processing of as raw data as possible. Furthermore, a detailed velocity model was built using FWI and traditional tomography tools. This was needed to solve an overburden challenge introduced by the edge of the Molo formation being present in parts of the survey area. This formation introduces a velocity contrast laterally and needs to be handled correctly. The final model provided a good fit to the depths of the wells used for QC. Later interpretation of the seismic data did not reveal any apparent non-geological features. In addition to conventional PSDM migration algorithms a test with a least squares migration was produced, the conclusion of this product was that it was in general too noisy to be used.

The final re-processed data was superior to the vintage data and used for the PL1058 seismic interpretation and mapping.

3.2 Seismic interpretation and mapping

The main dataset used for velocity model building and initial screening was the PGS18M05 and PGS17M05. Key horizons in the overburden were interpreted and at target level BCU, top Triassic and basement was mapped.

The PGS14005EQRZ PSDM dataset was the main dataset used for interpreting the JDE prospect and vital stratigraphy used in the prospect evaluation and well planning. The interpretation was done in time domain. The main well used for reservoir interpretation was 6407/10-3, however both 6407/10-4 and 6307/1-1 was used together with the structural restoration. The JDE prospect was interpreted to contain 2 reservoir sections, the main target of Carnian age and a lower reservoir section of early Carnian to late Ladinian. The lower reservoir was interpreted to be a thicker package underlying the upper Triassic unconformity, an expected break in the stratigraphy based on the restoration results. In the southeast area of the JDE prospect this section include a volcanic complex of likely Ladinian age.

The interpretation of the overburden was challenging as shallow gas is present intermittently in the whole area. Surfaces within seismic resolution was interpreted and correlated to the high-resolution site survey seismic and intervals below seismic resolution extrapolated to the well location and used in the well planning. A lot of efforts were put into this as this could impact well placement and potentially make the prospect difficult to drill at all. Due to the complexity of the overburden and shallow hazard situation, an early pilot was drilled down to lower

Brygge. This enabled the partnership to mitigate many of the risks and conduct an effective main well operation.

3.3 Structural restoration of the Frøya High, PL1058 area

A 2D kinematic structural restoration approach was applied to the southern Halten Terrace and Frøya High to understand the structural evolution of the area. The restoration was performed in a sequential stage to restore the fault movement during the Middle to Late Jurassic rift episode and provided the geometry of the earlier Triassic basins. The restoration technique was used as a validation test for the seismic interpretation as well as demonstrating the structural evolution through time. It is shown that the interpretation is consistent between the sections and consistent within the individual sections. Different steps of restoration were tested and alternative interpretations specifically between the two wells 6407/10-3 and 6407/10-4 located on the Frøya High were discussed. Integration of the restoration results together with well data and sedimentary environment analysis provided better understanding of the prospectivity, including source to sink concept of the reservoir and seal presence, in the southern Halten Terrace.

3.4 Geophysical observations and AVO analysis

Fluid substitution modelling using the 6407/10-3 well showed that a very subtle fluid effect in the Triassic interval. This is concluded to be due to the mud/silt content of the Triassic sandy interval observed in the well. Scenario modelling including 6407/10-3 observations, volcanics and a sandstone wedge interpreted as the prospective JDE reservoir, showed a good comparison to the seismic data. The modelling included porosity change with depth, fluid substitution, changing interfaces and variable thicknesses. Due to the composition of the Triassic sands and shaly intervals, classical AVO analysis was not regarded as good discriminator. The scenario modelling was used to understand the stronger reflections observed, defining the JDE prospect.

4 Well results and Post-Well update report

Exploration well 6307/1-2 targeted the JDE prospect in PL1058. The primary well objective was to test Triassic reservoir potential of Carnian to late Ladinian age. The JDE prospect is located at the northern part of the Frøya High. Favourable location up-dip proven mature source and discoveries. Main risks and uncertainty were related to the trap, seal and reservoir quality. Candidates for reservoir and intra Triassic top and base seal were identified in the 6407/10-3 well and in relevant analogues pre-drill. The prospect was had a well-defined reservoir container, forming a wedge shape up-dip towards the south from the 6407/10-3 well, see figure 4-1.

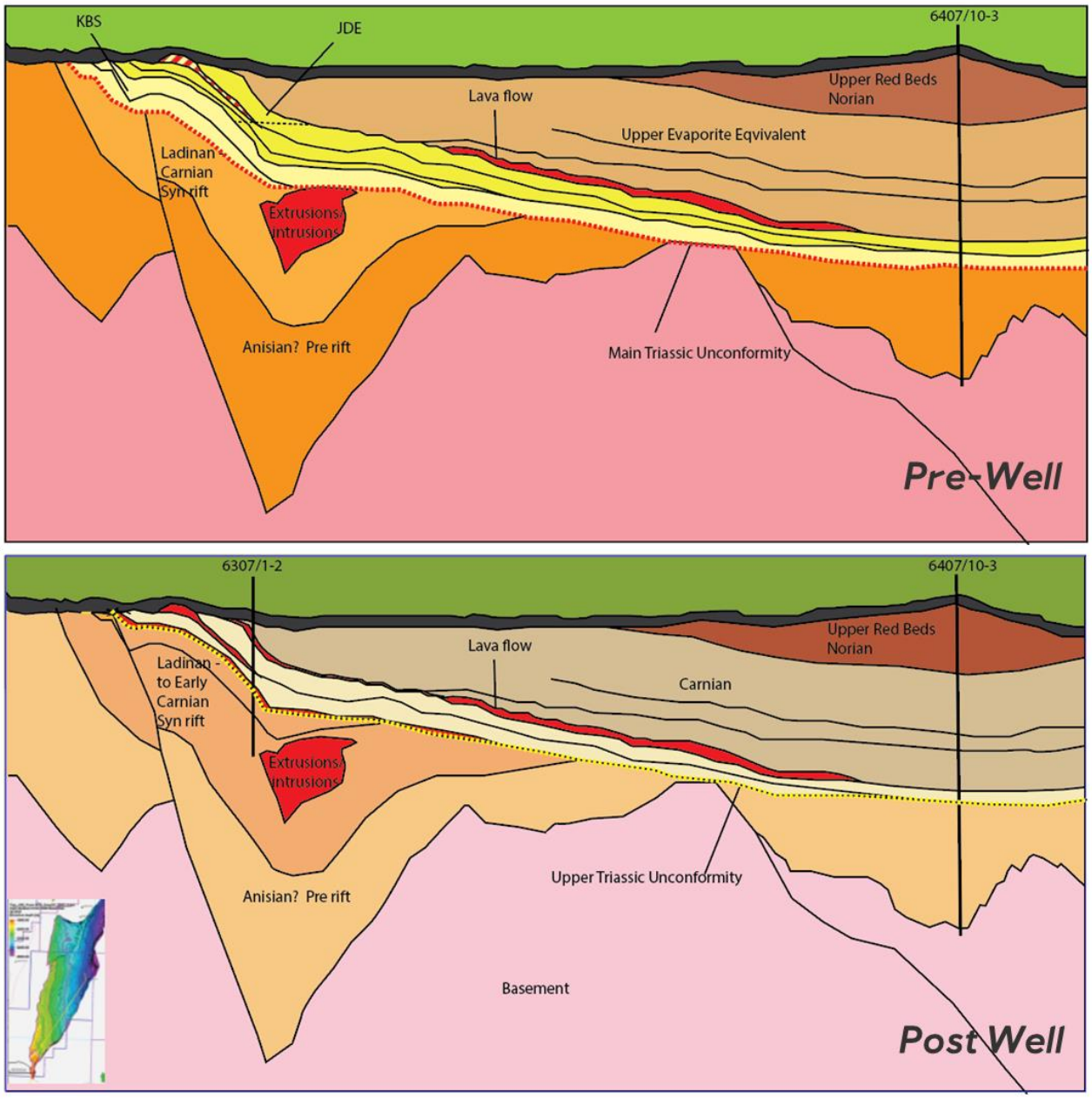

Figure 4-1: JDE concept pre-well & post-well.

The well came inn 15m deeper than prognosed at top Spekk and 17m at top Triassic. No upper Jurassic interval was found between Spekk and the Triassic. This was not expected, but a thin interval, below seismic resolution was in the risked outcome space. The interpreted top reservoir came in 11m deeper than prognosed. Coring was started at 1955m MD 3m shallow to top reservoir. Coring speed was very slow and approximately 1/2m pr. Hour, which was a result of hard rock and bit balling. As data acquisition was one of the main objectives of the JDE well, the licence ran 4 coring runs, where the first run was abandoned due to junk in the hole. A total of 27 m core was acquired and in the subsequent SWC run, 57 plugs were successfully acquired. In addition to the coring programme, a wireline programme including gamma ray, density, sonic, spectral GR, image logs, CMR, XPT and pressure points was carried out.

Post well studies included a full core analysis program, spectral core analysis of core and SWC's, biostratigraphy, petrology and geochemistry.

The well was dry, without traces of petroleum. No reservoir potential was encounter in the primary target and the deeper secondary target showed poor to limited potential. However, 3 episodes of volcanic activity was encountered. Lava flow 1 sits on top of the primary reservoir, the second flow corelates well with the acoustic hard response within the primary interval and the 3rd layer in the alternative reservoir interval. The post-well well-tie and subsequent gather modelling show good correlation between seismic and synthetic seismic. From a geophysical viewpoint the poor reservoir properties of the soft interpreted top reservoir reflector are attributed to the very high densities of the lava flow that sits on top of the reflector. Although, this layer is quite thin, together with the Spekk/ Triassic transition and tuning effects/ interference of the lava flow/ top reservoir reflection, a unique hard reflection is not resolved by the seismic resolution. The soft response is a product of a thin, but very high AI layer interfering with a high AI cemented mudstone underneath, although both high acoustic layers there is a major relative difference.

Post well seismic interpretation shows that there is limited prospectivety within the licenced area. This is based on the lack of reservoir and migration in the Triassic interval and that higher reflectivity layers are likely to have a volcanic imprint in the area. The remaining prospects & leads in PL1058 are Harahorn and Storen. The Triassic lead "Storen" was included in the TFO 2019 application. This lead greatly relied on reservoir and migration being demonstrated in the 6307/1-2 JDE well. Based on the conclusions of the JDE well, this opportunity remains a lead and was not matured to a prospect. Harahorn is a basement prospect also described in the 2019 TFO application. It was early abandoned due to estimated poor reservoir properties, small volumes and lack of producibility.

Table 3: Risk and volume summary remaining prospectivity

Prospect	Formation	Classification	Pg	Rec Vol[P90/Mean/P10] [Sm3]
Harahorn(*)	Basement	Prospect	0.08	4.16/ 27.5/ 60.2
Storen	Triassic	Lead	-	-
JDE	Triassic	Drilled	0	Dry

*) Playrisk applied

5 Technical evaluation

The 6307/1-2 JDE well was dry with no hydrocarbon shows. The Harahorn prospect was concluded not to be commercial, and no updated valuation were conducted, the Storen lead was not matured due to the re-mapping of the re-processed seismic and the results of the JDE well.

6 Conclusion

The Triassic and the basement play were the main drivers of the PL1058. The Triassic JDE prospect was tested with the well 6307/1-2 and was dry with no working reservoir or HC shows. This implies both a reservoir failure and a migration failure. The impact for any remaining prospectivety in the Triassic interval is limited and the basement play Harahorn was concluded to have verry low probability of any commercial success