

PL 742 Relinquishment Report

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The work obligations given by the Ministry of Petroleum and Energy (MPE) were as follows:

- Within 2 years: Reprocess existing 3D seismic data within awarded acreage. Make decision whether to drill an exploration well or relinquish (DoD).
- Within 4 years: Drill exploration well. Decision on concretisation or drop (BoK).
- Within 6 years: Perform conceptual studies. Decision to continue or drop (BoV).
- Within 7 years: PDO or drop.

Four partner meetings have been held in the license on the following dates:

- 04.03.2014 ECMC meeting #1
- 19.11.2014 ECMC meeting #2
- 07.09.2015 ECMC meeting #3
- 26.11.2015 ECMC meeting #4

The license work obligations (Phase 1) have been fulfilled. No viable prospectivity has been identified within the licensed acreage. Based on the results from the seismic reprocessing, special studies and internal work the Management Committee of PL 742 has concluded to not drill a well and to relinquish the license. A letter to notify the MPE was sent on January 13th, 2016.

2 Database

2.1 Seismic database

The seismic database (Fig. 2.1 and Table 2.1) for PL 742 consists of four public and one multi-client 3D seismic dataset (NX0802), covering the entire licence area. These five surveys were reprocessed and merged into one dataset, NH9401-DA-M14, by DownUnder GeoSolutions (DUG) in London.

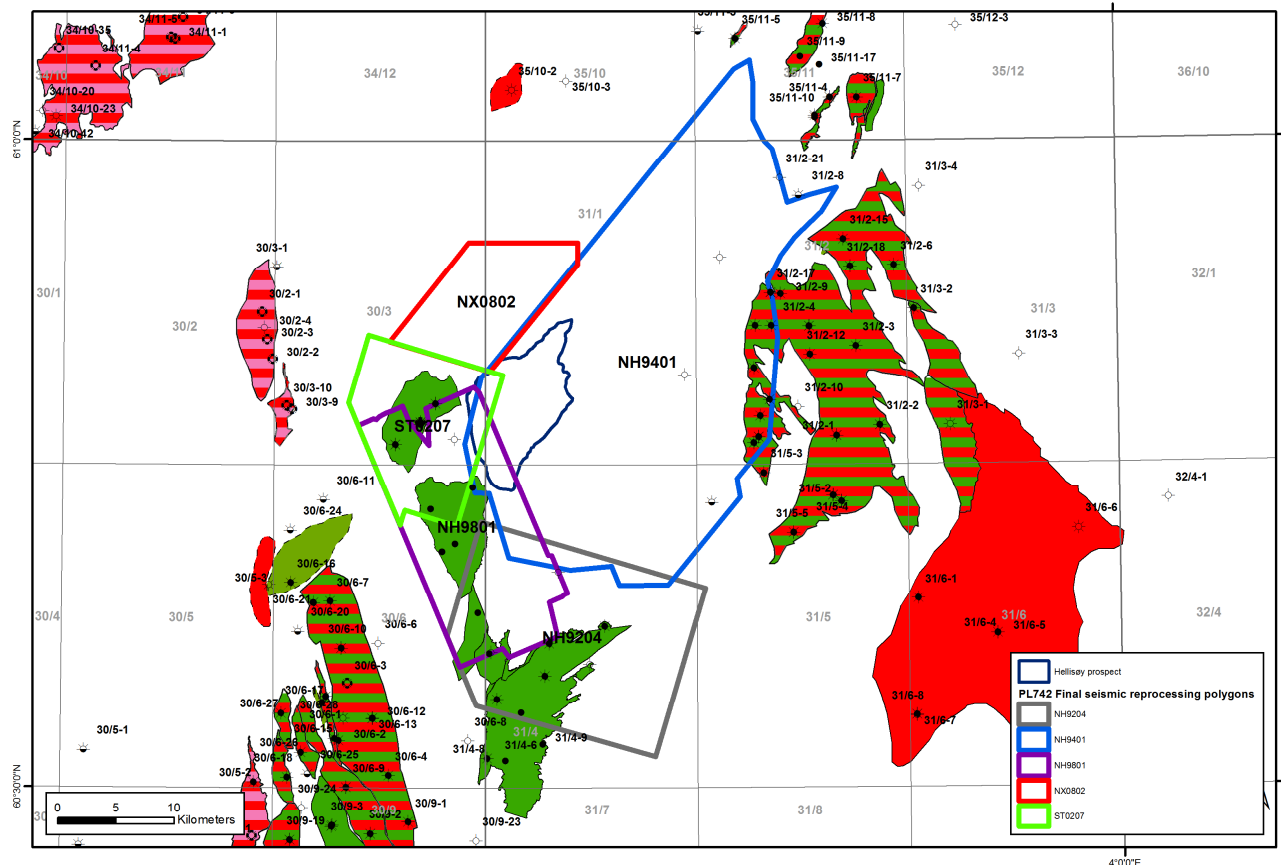


Fig. 2.1 Seismic database. Input surveys to the NH9401-DA-M14 merge and reprocessing.

Table 2.1 Seismic database

Survey	Acq. year	Area (km ²)	Direction (deg)	Streamers	Streamer length (m)	Streamer depth (m)	Source depth (m)	Low cut, taper	Rec. length (ms)
NH9401	1994	988	~40	4	3000	9	5	3Hz, 18dB/Oct	5120
NH9801	1998	161	~170	8	3000	7	5	3Hz, 12dB/Oct	5632
NH9204	1992	194	~110	3	3000	6	6	3Hz, 18dB/Oct	5000
NX0802	2008	100	~90	10	6000	8	6	3Hz, 18dB/Oct	6656
ST0207	2002	83	~106	8	4000	8	6	3Hz, 18dB/Oct	6144

The NH9401-DA-M14 dataset has a fully migrated area of 1300 km². Raw input data were provided by PGS and Statoil. The objectives for the processing were to merge of the five surveys into a consistent dataset over the area of interest, apply "broad-band" techniques to reduce side lobes and increase the seismic resolution, improve the demultiple sequence, and improve velocities and imaging. Fig. 2.2 shows a comparison between the dataset that was used as basis for the APA 2013 application and the reprocessed dataset.

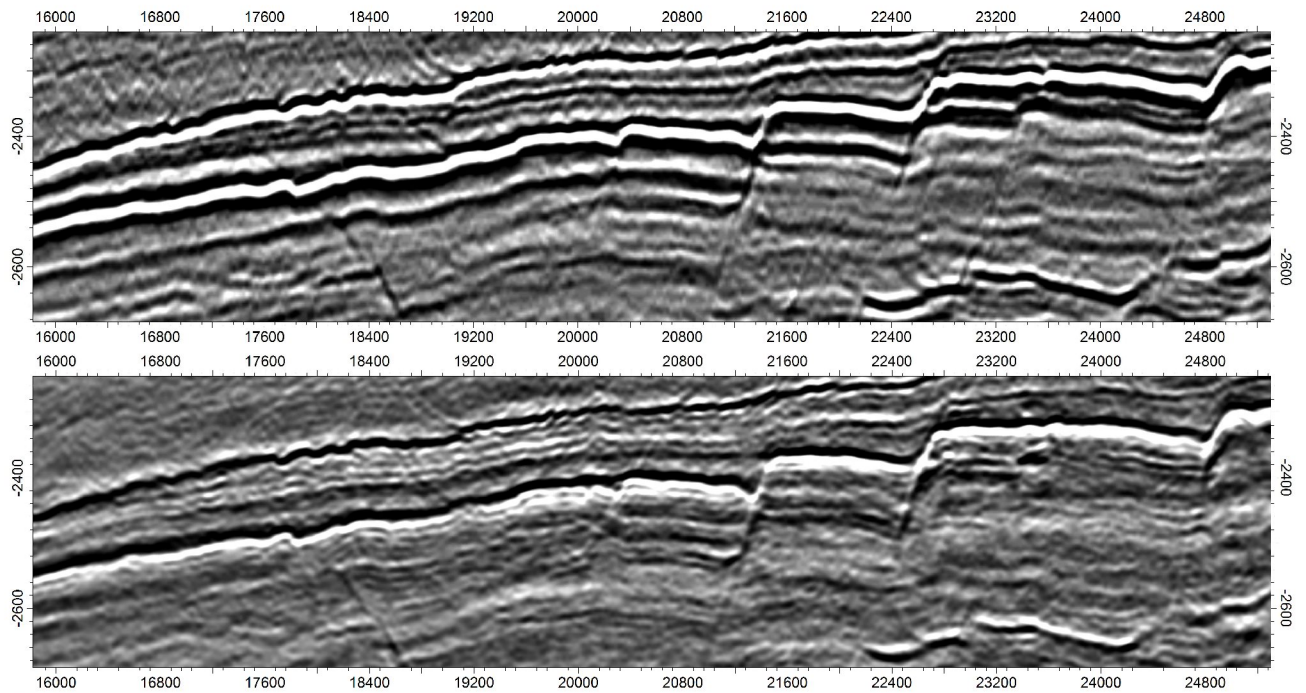
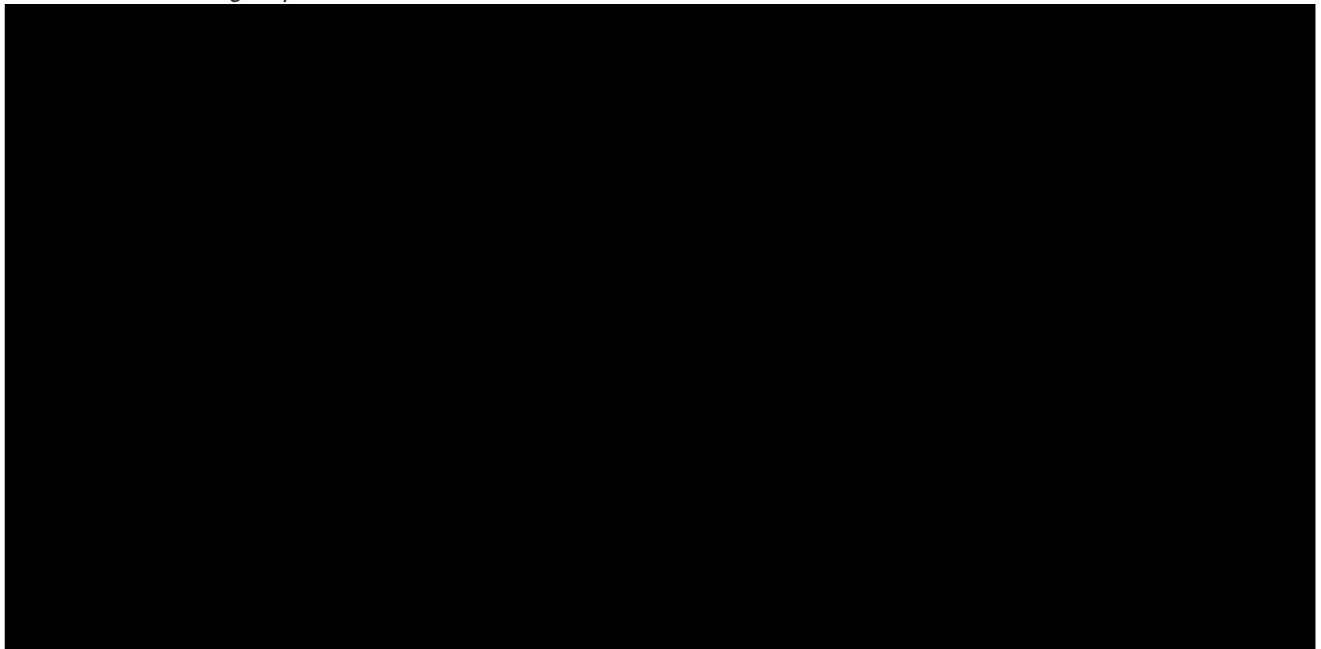


Fig. 2.2 Reprocessed versus original seismic data (XL1635). Upper section: Dataset used as basis for the APA application (NH9401R05); Lower section: Reprocessed dataset NH9401-DA-M14 (as provided by DUG). Note the improved resolution resulting from suppression of side-lobes in the reprocessed data. Further noise cancellation and spectral enhancement has been done in-house before interpretation.

The processing sequence is listed in Table 2.2. Further details may be found in the processing report.

Table 2.2 Processing sequence



The datasets delivered by DUG are listed in Table 2.3.

As prestack inversion was planned, data conditioning was required. Migrated gathers from the dataset were imported into PreStack Pro (in-house) to remove wave-transmission effects:

1. Random noise removal
2. Residual multiple removal (radon demultiple)
3. Flattening of primary events (trim statics)

Table 2.3 Processing deliverables

Datasets	Type of media	Format	File name	Date delivered
Pre-migration gathers after regularisation	USB	SEGY	regularised_pre-mig_gathers.sgy	11/06/2015
Final CMP gathers	USB	SEGY	NH9401_DA_M14_PstmGth.sgy	27/05/2015
Migration velocities	USB	SEGY	NH9401_DA_M14_MigVel.sgy	11/06/2015
Stacking velocities	USB	SEGY	NH9401_DA_M14_StkVel.sgy	11/06/2015
Full final stack	USB	SEGY	NH9401_DA_M14_FinStk.sgy	11/06/2015
Full raw stack	USB	SEGY	NH9401_DA_M14_RawStk.sgy	11/06/2015
Near raw stack with residual gain	USB	SEGY	NH9401_DA_M14_NearStk.sgy	11/06/2015
Mid raw stack with residual gain	USB	SEGY	NH9401_DA_M14_MidStk.sgy	11/06/2015
Far raw stack with residual gain	USB	SEGY	NH9401_DA_M14_FarStk.sgy	11/06/2015
UKOOA bin centre tape	USB	P1/90	full_bin_centre.ukooa	11/06/2015
Processing report	DVD	PDF	pl742Pr_002_ProcessingReport_150617.pdf	17/06/2015

Amplitude maps and cross correlation between near and far stacks were used to QC the process and ensure that the amplitudes were handled in an AVO friendly fashion during the processing, and that primary events were flat in the gather domain for accurate intercept and gradient calculations.

Having applied the above, partial stacks were generated for AVA and inversion studies (5 degree angle stacks), as well as full stack for interpretation and attribute purposes. Additional noise filtering and spectral enhancement were applied to the full-stack volume using the GeoTeric software from ffa.

2.2 Well database

Table 2.4 lists the wells comprising the license database and Fig. 2.2 shows the well locations (except the Buzzard location).

Table 2.4 Well database. Listed wells are those which have been used directly in special studies. Other wells in the area have been used in the interpretation, depth conversion and for general understanding. Well positioning, wireline logs, checkshot data and deviation surveys were obtained from the DISKOS database. The NPD's lithostratigraphic nomenclature for formation tops was used in well correlations and zonation. Only public well data have been used.

Well	TD (m MD)	Oldest penetrated age	HC	Year	Rock physics	Biostrat	Provenance
NO 30/3-2 R	3567	Triassic	Oil/Gas	1981		x	
NO 30/3-3	3419	Early Jurassic	Dry	1983			x
NO 30/5-3 A	4746	Late Jurassic	Gas	2009		x	
NO 30/6-14	2900	Early Jurassic	Oil	1984		x	x
NO 30/6-22	3336	Early Jurassic	Oil	1988		x	x
NO 31/1-1	2920	Early Jurassic	Dry	2008	x	x	x
NO 31/2-14	1725	Middle Jurassic	Oil/Gas	1984	x		
NO 31/2-19 S	4114	Early Jurassic	Dry	1996	x		
NO 31/4-4	3150	Early Jurassic	Dry	1981		x	x
NO 31/4-11	3271	Early Jurassic	Oil/Gas	2000		x	
NO 31/5-6	2370	Early Jurassic	Oil shows	2000	x		x
NO 35/11-11	3225	Early Jurassic	Shows	1998		x	
UK 20/6-3 (Buzzard)	2863	Triassic	Oil	2001	x		

Well selection criteria

The well selection is based on location relative to the prospect area (Fig. 2.3) and on relevance for the various studies to be undertaken. For the rock physics evaluation (input to well ties and seismic inversion) it was important that the wells all lie within one single seismic survey. The exception here is the Buzzard well (UK 20/6-2), which was chosen as a potential analogue and presumably representative for the shale and reservoir characteristics of the main prospect targeted in PL742. The eight wells sampled for the biostratigraphy study were selected based on presence of intra Draupne Formation sandstones, presence of Late Jurassic and Early Cretaceous intervals, proximity to the license area, structural setting, and availability of sample material. For the provenance study, sink wells were chosen based on proximity to the prospect, whereas source wells were chosen based on presence of potential source material (e.g. Sognefjord Formation).

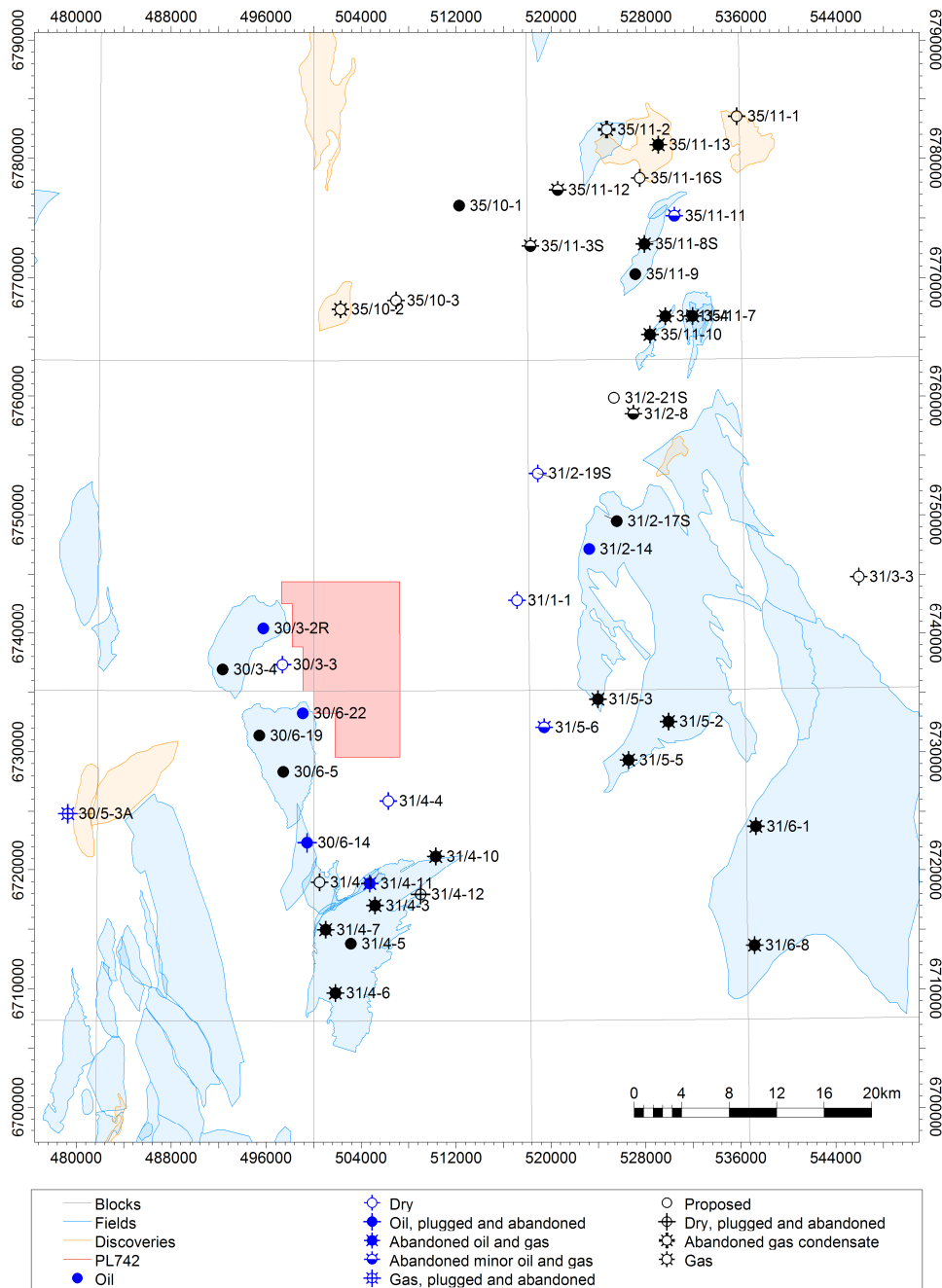


Fig. 2.3 Well database. Blue symbols indicate wells that have been used directly in special studies. Other wells have been used for interpretation purposes.

3 Review of geological framework

This section summarizes the main results of the geological and geophysical evaluations and special studies carried out since the award in 2014. The main focus has been on interpretation of seismic data, reservoir characterization and on understanding the structural and depositional history on the Lomre Terrace during the Late Jurassic period, targeted at the initially identified prospect - the intra Draupne Hellisøy Prospect. However, as work progressed and the evaluation of the initial prospect proved discouraging, attention was turned to other stratigraphic levels of potential interest. These were late Middle Jurassic to early Upper Jurassic intra-Heather sandstones (Sognefjord, Fensfjord and Krossfjord formations), Middle Jurassic Brent Formation and Paleocene intra-Lista Formation sandstones.

Seismic interpretation and analyses

The main interpreted horizons are the Seabed, Top Hordaland Group, Top Paleocene, Top Shetland Group, Top Cromer Knoll Group, Base Cretaceous Unconformity (Fig. 3.1), Top Draupne Formation sandstone (J64), Base Draupne Formation (J62), Top Middle Jurassic and Top Dunlin Group (Fig. 3.2). A detailed interpretation of the full (and in some instances far) offset stack(s) has been carried out.

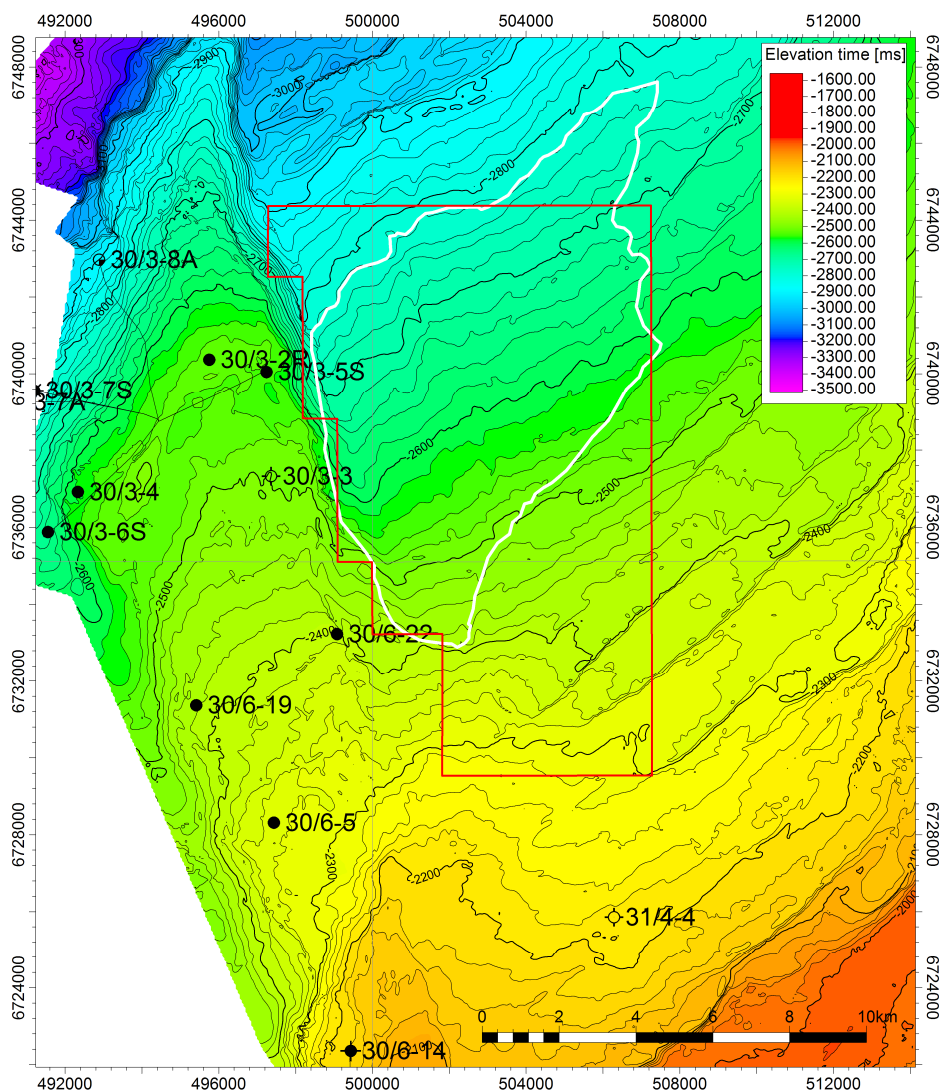


Fig. 3.1 Base Cretaceous Unconformity (TWT). Top of the Draupne shale interval. The white outline marks the Hellisøy Prospect. The red outline marks the PL 742 license area.

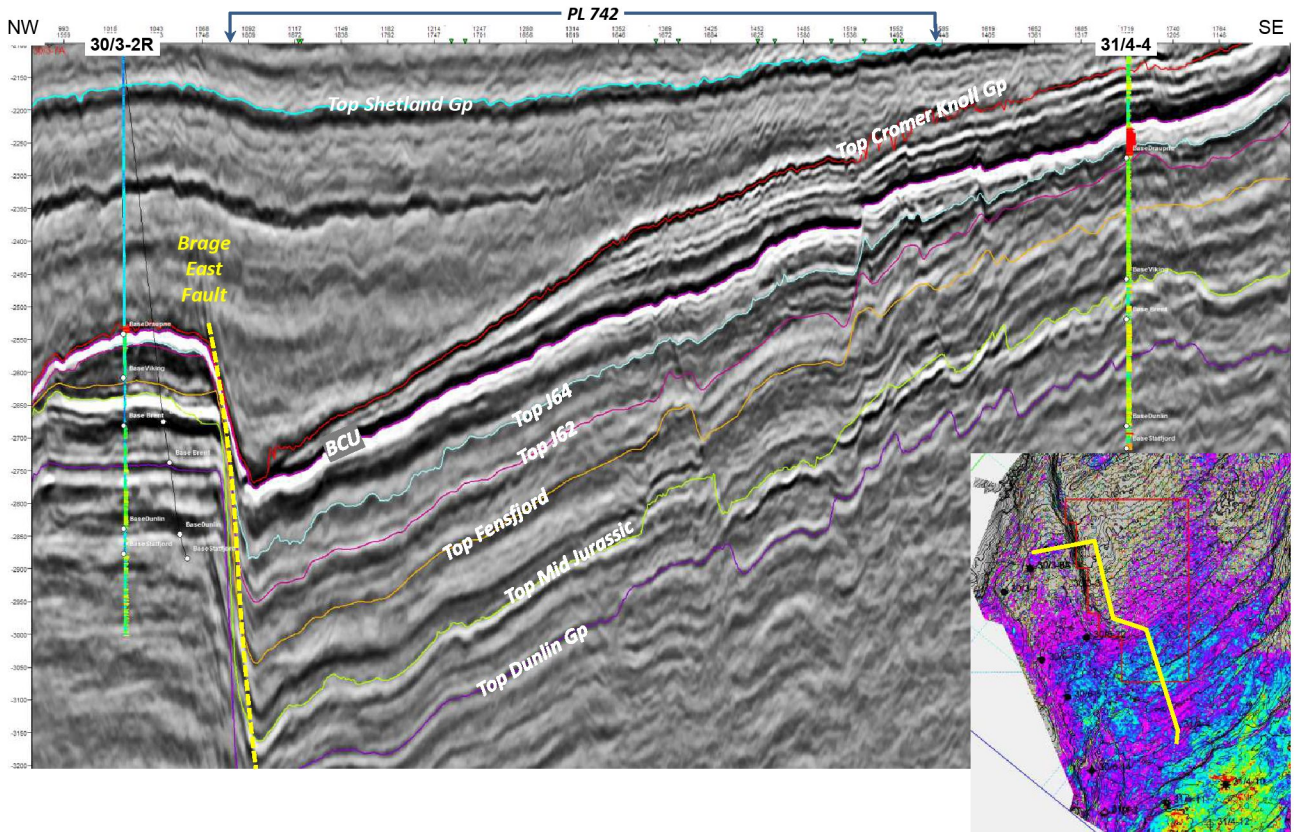


Fig. 3.2 Seismic random line across PL742. Interpreted surfaces (except top Paleocene, top Hordaland and seabed) are shown. The index map is extracted from the reservoir indicator cube in the target interval.

The lithostratigraphic framework for the Middle to Late Jurassic strata in the northern Viking Graben is shown in Fig. 3.3.

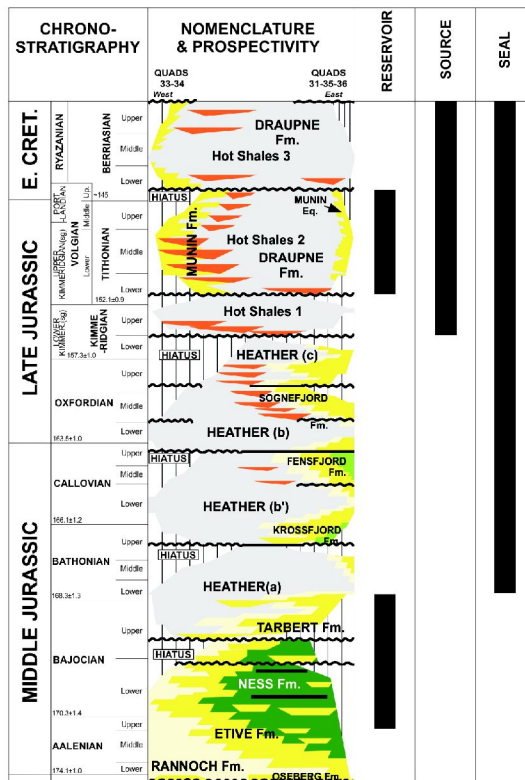


Fig. 3.3 Stratigraphic chart, northern Viking Graben. Modified from Geolink (2009).

The Hellisøy Prospect was defined in the APA 2013 application as an intra Draupne Formation sandstone deposit on the basis of a thickness anomaly in the Draupne interval on the Lomre Terrace on the east side of the Brage Horst (Fig. 3.4). In order to confirm the presence of reservoir, the acquired seismic dataset was investigated by means of seismic inversion, AVO and attribute analyses within the framework established by the structural interpretation of the data.

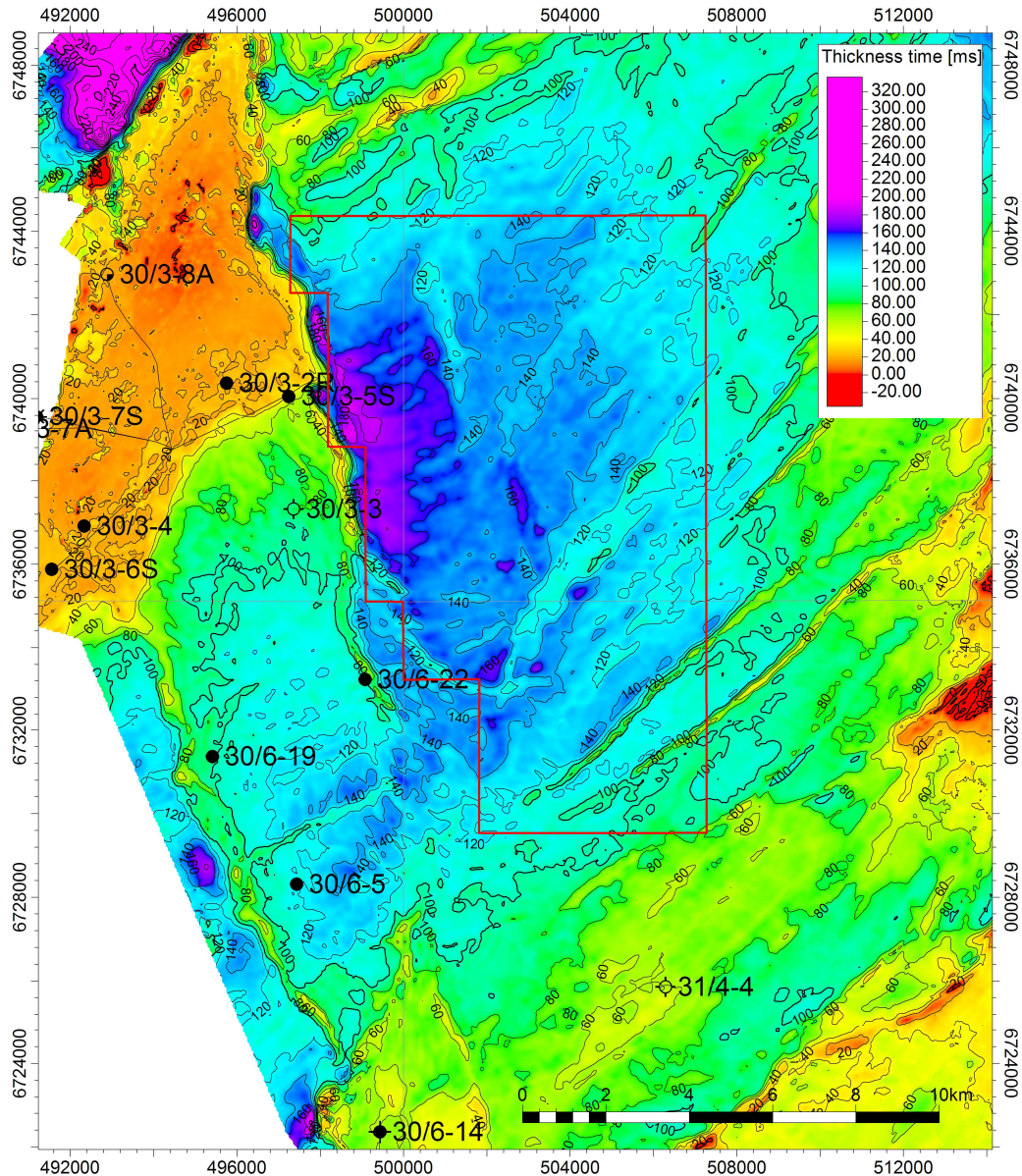


Fig. 3.4 Draupne Formation thickness (TWT). Note maximum thickness up to 180 ms against the Brage East Fault.

Rock physics

Rock Solid Images (RSI) prepared five wells for use in in-house work/studies (well ties and seismic reservoir characterization; ref. Table 2.4). Deliveries comprised edited and QC'ed logs (CPIs and elastic logs) and complete intra-elastic relationships (RHOB-Vp, Vp-Vs).

Seismic inversion/reservoir characterization

Angle stacks ranging from 5 to 25 degrees were used for the seismic reservoir characterization study. The wavelet was estimated from tying logs to the various stacks resulting in a symmetric wavelet with negative main lobe. The simultaneous inversion (Aki and Richards approximation; Ikon Science software) was used to produce the basic output rock properties: P impedance and Poisson's ratio.

In PL 742 the BCU marks a regional contrast between the marly Cromer Knoll Group and the soft, over-pressured Kimmeridge clays in the Viking Group. An exponential non-reservoir compaction trend guide was used to minimize the depth trend differences for the various logged Viking Group intervals using the top Balder surface as datum. The resulting non-reservoir trend flattens out at ~1 second below top Balder and corresponds to a lower boundary where the non-reservoir rock porosity approaches zero.

To interpret the inversion results the output properties were combined to a lithology indicator cube, which basically is a P-Impedance distance to the $V_{\text{clay}}=50\%$ curve. This cube highlights non-reservoir rocks as positive values and quartz-rich rocks (both wet and oil saturated reservoir rock types) as negative values. The maps extracted from this indicator cube should be of minimum value type - more negative values signify higher likelihood for oil content. An potential pitfall in interpreting lithology indicator results is property tuning: Even broad-band, seismic-derived rock properties exhibit tuning effects straight above or below large rock property contrasts. This effect can only be minimized through initial model building using surfaces to control the contrast location. Nevertheless, in PL 742 a spurious reservoir-type response was found close to the BCU. A valid interpretation of the reservoir indicator can therefore only be found away from the BCU contrast, as exemplified by the Draupne J64-J62 interval where indicators of wet sand are found in the southernmost quarter of the license area (Fig. 3.5).

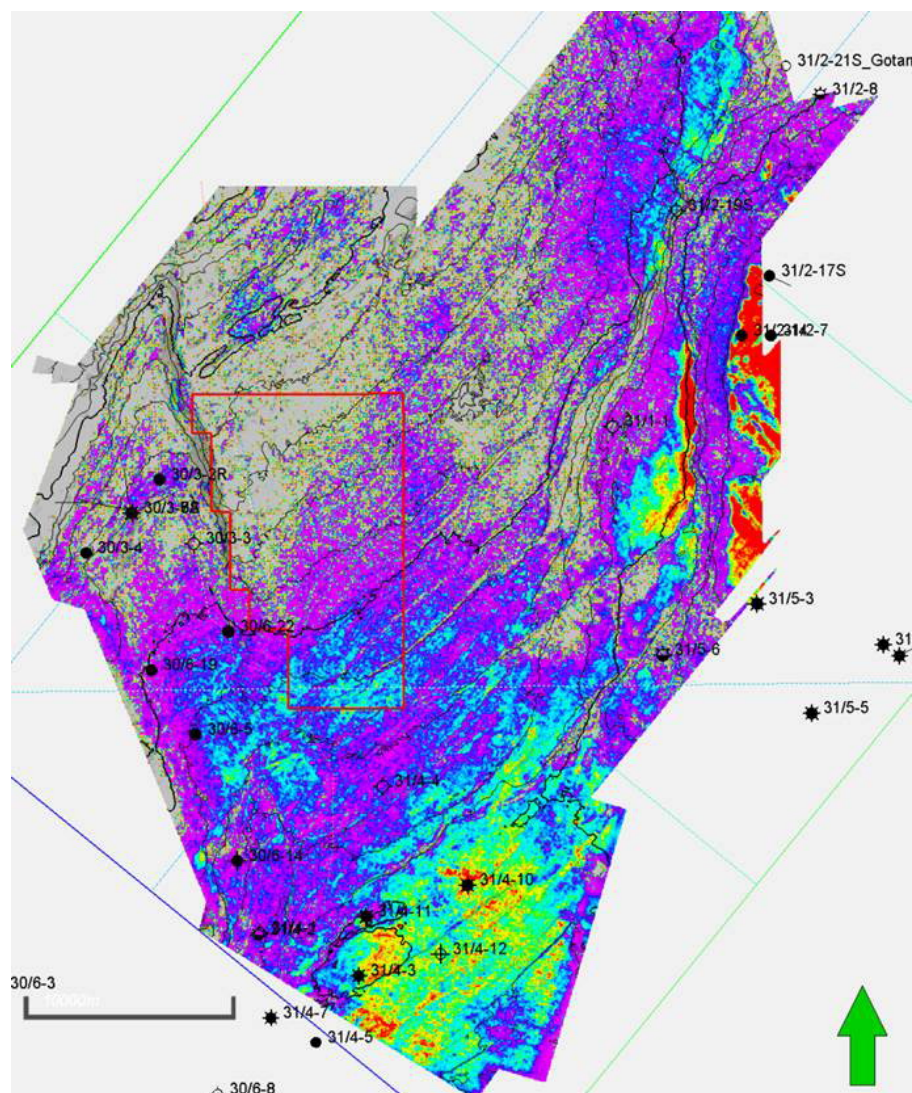


Fig. 3.5 Reservoir indicator. Reservoir indicator from the seismic AVA inversion indicates presence of reservoir in southern part of PL742. Attribute: sum of negative values between top J64 and top J62. Warm colours are high negative.

AVA Class 2p anomalies are also identified at two levels in the Paleocene Lista Formation. The anomalies are single cycle events with a broad extension. Neither of the anomalies in the Paleocene conform to structure, and are therefore not believed to be fluid indicators. Fluid substitution was performed for the Paleocene interval in well 31/2-19 S in order to understand these seismic AVA responses.

Attribute analysis

A suite of seismic attributes have been investigated using both Petrel and GeoTeric. The most useful ones proved to be those related to seismic amplitude (RMS, summed amplitude). GeoTeric was used both to improve the full stack volume (noise cancellation and spectral whitening) for seismic interpretation and to search for geologically meaningful clues to the depositional environment and processes, mainly by investigation of the frequency components in the seismic data through RGB analysis. Unfortunately, the latter did not yield any convincing results.

Geological studies

Biostratigraphy

A phased study was carried out by PetroStrat in which biostratigraphic data for selected wells were integrated and evaluated. The objective was to facilitate understanding of the temporal variation in tectonic activity and the main transgressive/regressive episodes controlling the Lower Cretaceous - Upper Jurassic stratigraphy. In the first phase a review of vintage biostratigraphic data was undertaken. Such data were found to be poor to non-existent, especially in quadrant 31. Hence, identified lithostratigraphic units and MFSs are associated with relatively low confidence. Vintage lithostratigraphic nomenclature was also found to be inconsistent. In phase 2, therefore, routine biostratigraphic analyses was carried out on ditch cuttings and core pieces from eight wells (Table 2.4). Palynological recovery is often poor in the Cretaceous intervals, possibly due to the carbonate nature of the sediments and lack of argillaceous deposits. However, the deeper marine facies of the Draupne and Heather formations allow for the proliferation of dinocyst taxa and more confident age determination within the Jurassic intervals.

The oldest sediments analysed in the wells are marine, heterolithic sediments of the Heather Formation. The stratigraphic relationship of the Heather Formation to the overlying anoxic, organic rich claystone Draupne Formation is generally unconformable, however the sequence boundary observed in wells 30/6-22 and 30/3-3 on the Brage Horst are likely conformable. The Draupne Formation is characterised in all wells by the proliferation of Prasinophyceae algae and an increase in amorphous organic matter - supporting the interpretation of a marine, anoxic depositional environment.

The Draupne Formation is unconformably overlain in all wells, with the exception of wells 31/4-11 and 31/4-4. In well 31/4-4 no evidence of a stratigraphic break was observed between the overlying Cromer Knoll Group and in well 31/4-11 a major stratigraphic break was observed within the Cromer Knoll Group.

Provenance/sedimentology

The objective of this study, performed by CGG Robertson, was to investigate source to sink relationships around the PL 742 licence. This focuses on source wells 30/6-14, 31/1-1, 31/4-4 and 31/5-6 on the adjacent highs, which display a similar shallow marine source facies, and sink wells 30/3-3 and 30/6-22, where the Draupne Formation occurs as a result of reworking and deposition in the Upper Jurassic. The aim was understanding the provenance and mass-flow movements in the region during this time.

Evaluation results

Draupne Formation

A 65 m thick Draupne shale interval is observed in well 31/4-4, located southeast and upflank of the licence area. This interval thickens downflank to a maximum of ~180 milliseconds up against the Brage East Fault (Fig. 3.2 and Fig. 3.4). It was hence speculated that the thickness increase could be explained by a sandy deposit in the Draupne interval, not previously targeted in the area.

Based on biostratigraphic analysis in wells 35/11-11, 31/4-11 and 30/5-3A, the top of the Intra Draupne Formation sandstone is interpreted to correlate with the J64 Maximum Flooding Surface (MFS), whereas base Draupne Formation is picked near J62. The geological ages of J64 and J62 are 152 Ma (Early Tithonian) and 156 Ma (Early Kimmeridgian), respectively.

Structural and paleogeographic reconstruction based on the biostratigraphy data and the detailed interpretation the Dunlin-Cromer Knoll interval indicate that a depocenter was present in the license area during J64-J62 times (Fig. 3.7). Correlation of biostratigraphic sequences between wells on the Brage Horst and on the Horda Platform suggests that the depocenter on the Lomre Terrace extended southwestwards over what is now defined as the Brage Horst, such that no barrier to mass transport of sediment from the Horda Platform was present along the Brage East Fault during deposition of the Draupne Formation. The relief observed on the Brage Horst was likely developed during the Cretaceous. The implication from this is that any sands deposited within this accommodation space would be difficult to seal off within the license boundaries unless by fault displacement. Displacement on the Brage East Fault diminishes to the south and is effectively zero near the southwestern corner of the license.

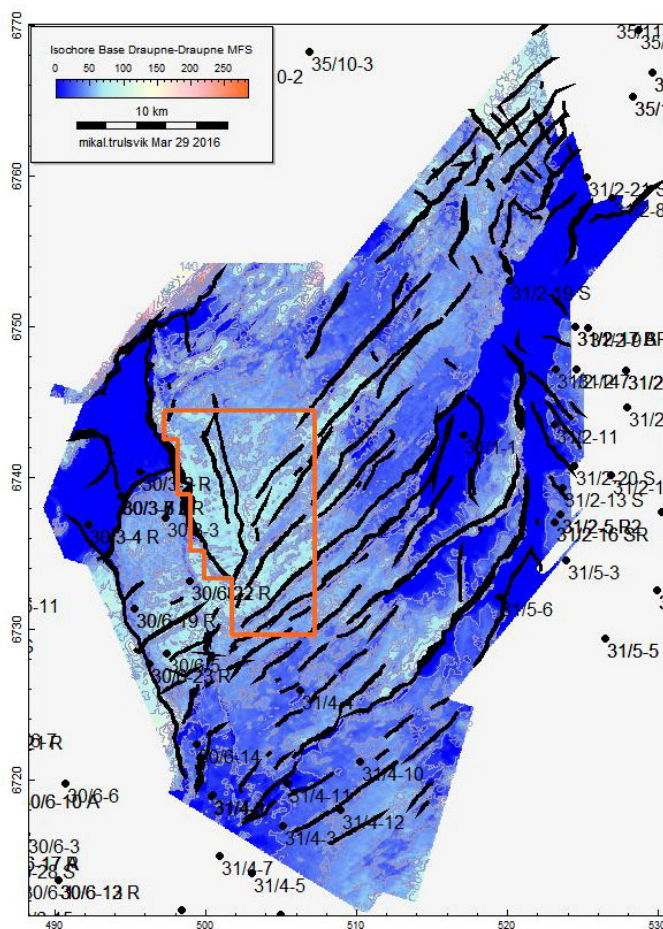


Fig. 3.7 Draupne isochore (J64-J62/Tithonian). Isochore units: milliseconds TWT.

The map in Fig. 3.6 shows extracted values from the AVO cube between the top and base of the presumed intra Draupne reservoir interval. A reasonably good correspondence between AVO anomalies and proven hydrocarbon occurrences testified to the validity of the data. Mismatches (e.g. the Brage Field) can be explained by vertical resolution issues and tuning effects along the Base Cretaceous Unconformity surface. Compared with the reservoir indicator map in Fig. 3.5, a good correlation is observed - as should be expected if some hydrocarbon saturation is present.

Both the reservoir indicator and AVO cubes indicate some response in the intra-Draupne J64-J62 interval. Top and base surfaces for this interval were interpreted on the full-stack data and values from the reservoir indicator and AVO cubes were extracted. It became clear that there was no reservoir response in the Hellisøy Prospect. Responses from both reservoir and AVO datasets are evident (but not contained) within the southeast corner of the license area. The anomalies extend southwards onto the Brage Horst and is thus in close agreement with the Late Jurassic accommodation space seen from the structural reconstruction (Fig. 3.7). The anomalies also continue eastwards upflank. Since no structural closure exists and the NE-SW trending faults are unlikely to be sealing as they approach the Brage Horst, efficient trapping of hydrocarbons within the license area is doubtful. The lack of reservoir in the initial Hellisøy prospect and the lack of trap in the region where reservoir may be present forced the conclusion that the Draupne level is void of commercial potential.

Heather/Fensfjord Formation

In well 31/4-4, Sognefjord and Fensfjord formation sandstones with gross thicknesses of 39 m and 45 m, respectively, were encountered. In the Sognefjord Formation the net sand interval is 24 m and consists of fine-grained to very fine-grained argillaceous, micaceous sandstone. Average porosity is calculated to 16 %. A similar lithology is observed in the Fensfjord sandstone. No Krossfjord Formation was found.

The interpretation of the Fensfjord Formation was extended northwest from well 31/4-4, however no trap could be defined as the interval is truncated by an unconformity or pinches out south of the license area. The Sognefjord Formation is most likely truncated towards the northwest and there is no evidence for its presence within the license area.

Brent Group

The top Middle Jurassic surface is well defined in the area of interest. No trap has been defined within the license area.

Paleocene Lista Formation

Two single-cycle seismic events are observed in the Paleocene section partially inside the license boundaries (Fig. 3.8). Whereas they do not stand out on the near trace cube, they brighten significantly on the far and ultra-far cubes, exhibiting Class 2/2p (or Class 3 AVO) response (Fig. 3.9). Well 31/2-19 S to the north of the license area has 131 m of intra-Lista Fm sandstone of excellent quality with weak shows. Several wells in the Fram area to the north (35/10-1, -3, 35/11-3 S, -5) exhibit various amounts and quality of Paleocene sandstones. Oil was observed in 35/10-1 and good oil shows were detected in 35/10-2. The Paleocene thickness decreases from north to south; the wells on the Brage Horst have no Paleocene sandstones. One interpretation of the observed anomalies in the PL742 area is that they represent a distal lobe/sheet facies.

Fluid substitution of the intra-Lista Fm sandstones in 31/2-19 S (Fig. 3.10) indicates that a thin sand body (10 m) should give a Class 2p response for all cases (brine, oil and gas) with only a slight increase in amplitude for the gas case. A thick sand body (100 m) on the other hand results in a weak Class 2 response for the wet case, and a strong Class 3 response for the gas case. A sand thickness of approx. 30m will push the AVA response from Class 2p to Class 2. As the observed anomalies in PL742 exhibit a Class 2p response it is difficult to determine what type of fluid is present (Fig. 3.11).

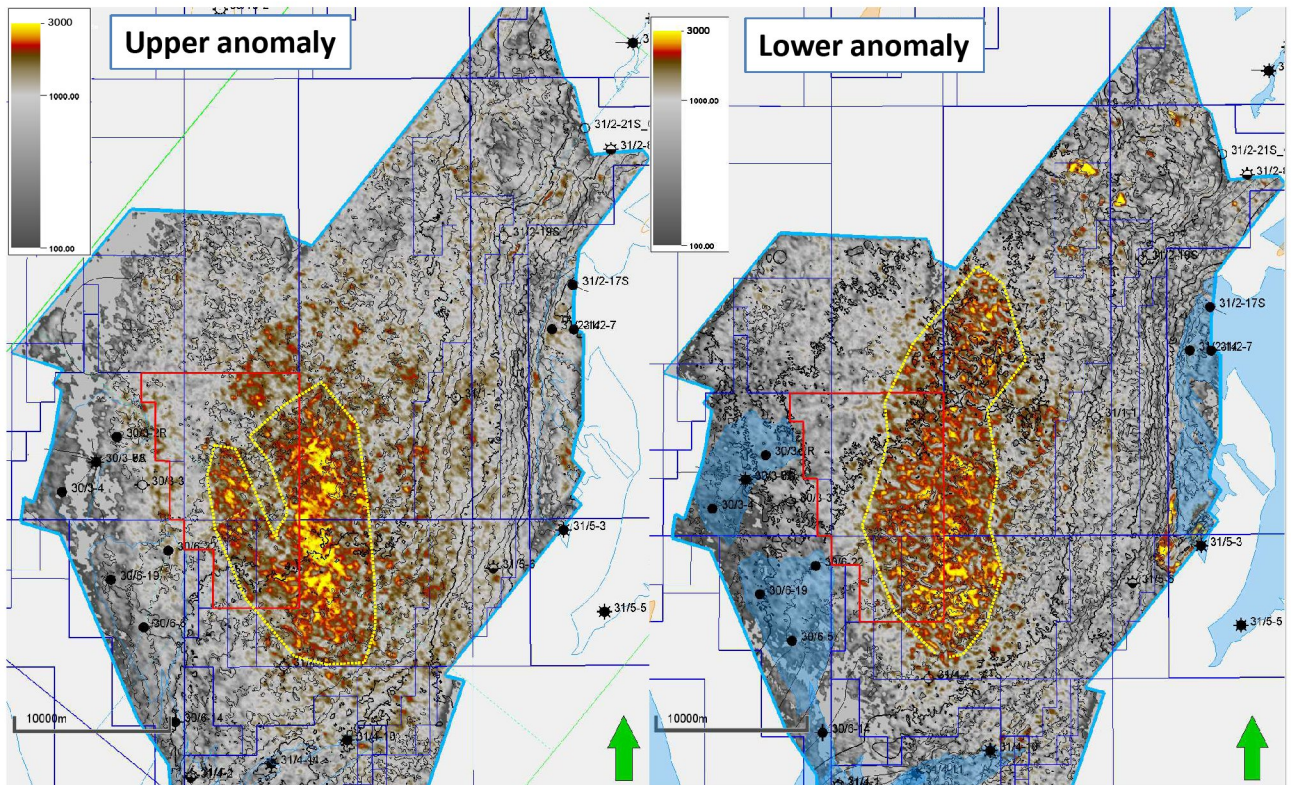


Fig. 3.8 Paleocene anomalies - map. Attribute: Average positive amplitude +/- 8ms, ultra-far stack (39°-44°).

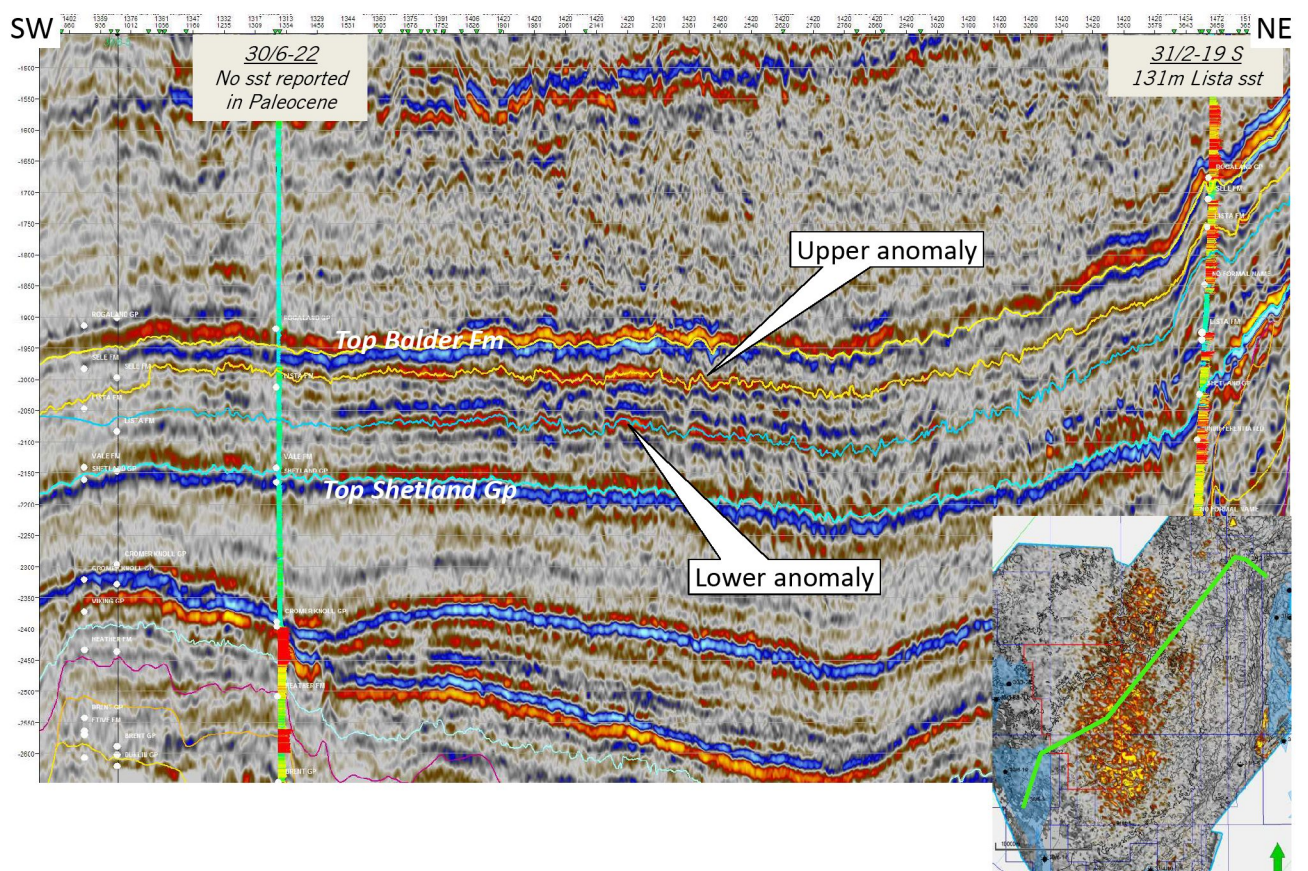


Fig. 3.9 Paleocene anomalies - seismic section. Seismic random line showing ultra-far stack through the two single-cycle events.

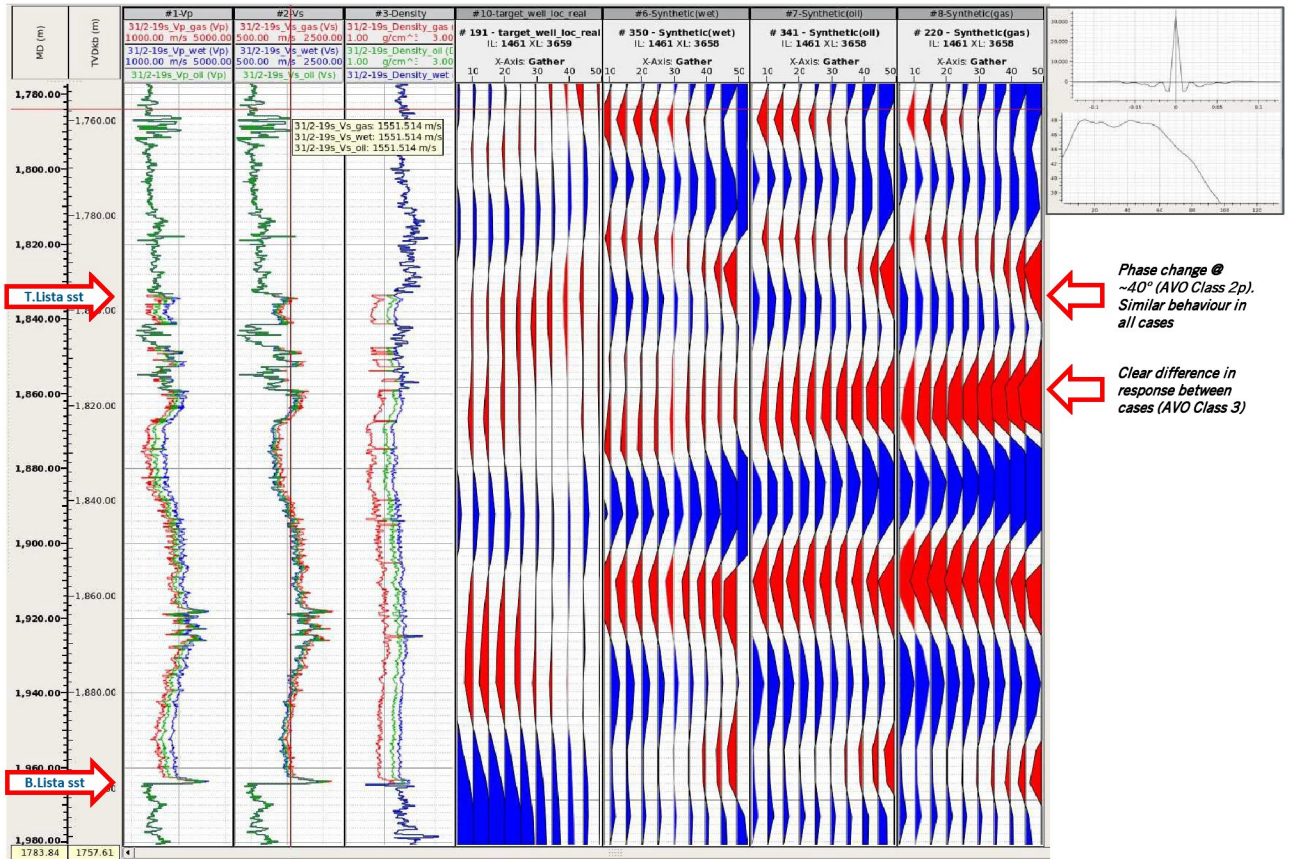


Fig. 3.10 Fluid substitution, well 31/2-19 S

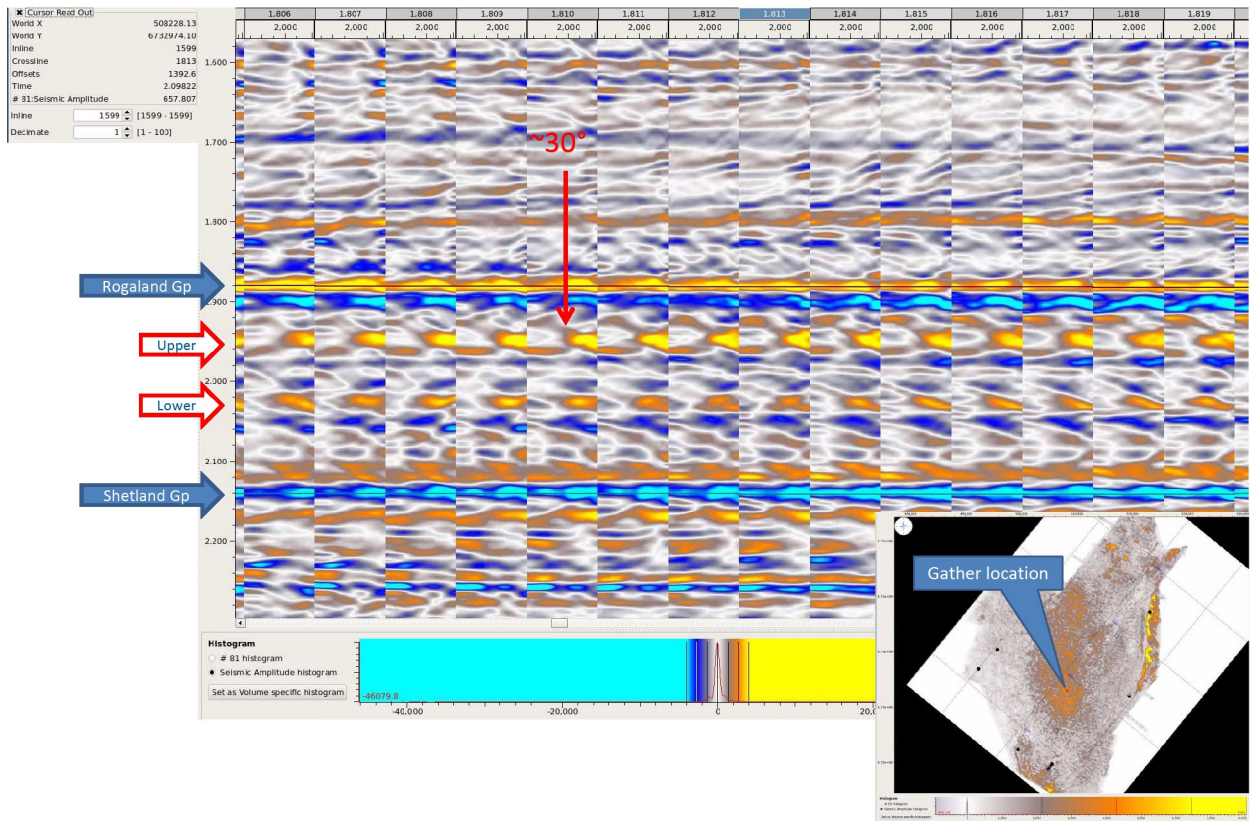


Fig. 3.11 Paleocene anomalies - AVO gathers. Gathers from a location within the anomalies exhibit Class 2p AVO response. The cross-over occurs at ~30 degrees.

No convincing amplitude shut-off with depth is observed, no structural closure is present and most of the anomaly on both levels is outside of the license area. Hence, no prospect could be defined in PL742.

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4 Prospect update

Dana's APA 2013 application covered the Upper Jurassic Hellisøy Prospect in blocks 30/3, 31/1 and 31/4 and the Middle Jurassic Brent Group Fedje A and B leads in block 31/4. Only the Hellisøy prospect area was awarded to Dana, hence post-award work did not include the Fedje leads. Fig. 4.1 shows the application versus the awarded areas along with the Hellisøy Prospect and Fedje leads outlines.

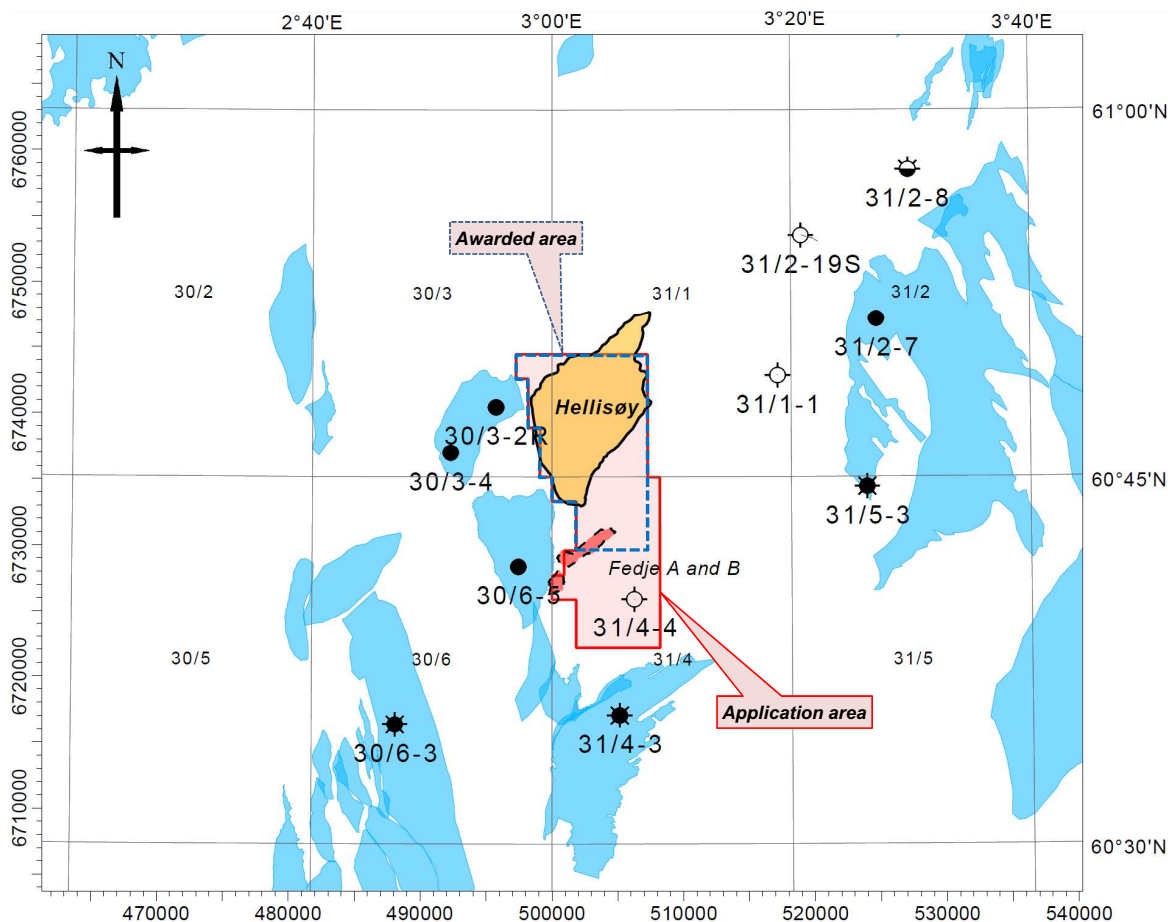


Fig. 4.1 Awarded versus application area. Only the down-flank part of the Fedje A lead was included in the awarded area.

As described in Chapter 3, the Hellisøy Prospect was based on the presence of a thickness anomaly in the Draupne package against the Brage East Fault. The seismic reprocessing was targeted at increasing the vertical resolution in the hope that any intra Draupne sandstones in this area could be detected. The resulting seismic dataset NH9104-DA-M14 was considerably improved in terms of resolution (as shown in Fig. 2.2), but failed to show any presence of reservoir in the Hellisøy location. Other observations and potential leads/opportunities within the license area have been pursued, but none have proved material.

Volumetrics and risking

Since no viable prospects have been defined, no risking or volumetric analysis have been carried out. For the original Hellisøy Prospect the probability for reservoir would be close to zero, giving an very low or zero total probability for success (POS). The trap probability for the intra-Draupne anomaly in the southern part of PL742 would also be close to zero. The same applies to the Fensfjord/Sognefjord and Brent levels - total POS would be negligible due to trap risk. The observed Paleocene anomalies suffer high risks/low POS (0.1-0.5) on several elements: trap, reservoir and charge (including fluid type). Given these conditions, it was not considered relevant to perform volumetric assessments.

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5 Technical evaluations

No technical evaluations have been performed.

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6 Conclusions

No material prospects have been identified within the PL742 boundaries

- Middle Jurassic: No structural closure identified within license; upflank fault seal is unlikely
- Upper Jurassic: Possible reservoir and fluid responses are observed partly inside but mainly upflank of license. No closures (structural or stratigraphic) have been identified. There are no indications of reservoir in the original Hellisøy Prospect.
- Paleocene: AVO anomalies in two levels are observed, extending out of the license upflank. Only weak/uncertain shows in the closest offset well 31/2-19 S (according to NPD fact pages). The risks on reservoir, trap and fluid are too high.

The license group therefore decided not to drill an exploration well and to relinquish the license within the deadline of February 7th, 2016.

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7 References

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