

PL 868

Relinquishment Report



Partner:



Relinquishment Report PL868

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1 Introduction

1.1 License Group

The license was awarded Aker BP ASA 60% as operator, and Statoil Petroleum AS 40% as partner. In 2018 Statoil became Equinor Energy AS. Current license group consists of Aker BP 60% (operator) and Equinor 40 %

1.2 Award and work program

The license was awarded 10.02.2017 as part of TFO2016, with a work program to reprocess 3D seismic, perform G&G studies and to make a drill or drop decision within two years. Two license extensions for the Drill or Drop deadline have been granted, the first due to inclusion of OBN seismic (AX18200) and the second for the subsequent late delivery of the OBN data. Thus the final drill or drop decision in the license after extensions was 10.02.2021.

An overview of partner meetings can be found in Fig. 1.1

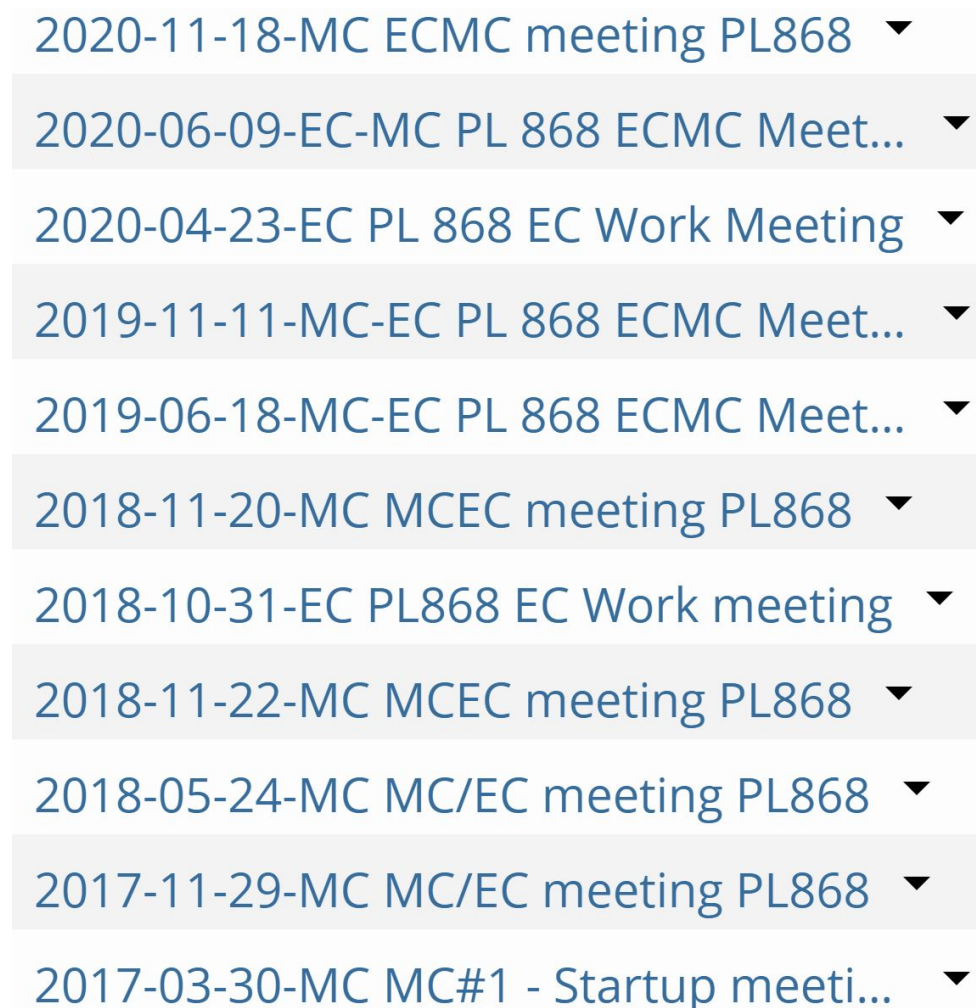


Fig. 1.1 License meetings in PL868

1.3 Identified prospectivity

Three prospects have been evaluated within the license: Stuttgongkampen (Vestland gr.), Nautgardstinden (Vestland gr.) and Styggehoe (Viking gr.), all of them downfaulted hanging-wall structures with main risk identified as fault seal and/or migration.

In April 2016 Aker BP drilled two exploration wells from the Ivar Aasen platform; 16/26S -and A. The main target for these two exploration wells were additional hydrocarbon potential in two hanging-wall structures comprising the Vestland Group as main reservoir, east of the West Cable discovery. The results of the wells were one small discovery (26S) and a dry well (26A). After incorporating the well results in the license work, the Nautgardstinden together with the overlying potential in Upper Jurassic (Styggehoe) was regarded as the main prospect.

All of the prospects have been evaluated on the new OBN seismic survey AX18200. This has increased the confidence in the mapped structures and the understanding of the prospects, but the operator has not been able to de-risk the prospectivity. There is still significant risk on fault seal for all three prospects and in addition, migration, on the PL868 main prospect Nautgardstinden. High risk in combination with low prospect volumes inside the license area, led to the decision to drop the license.

2 Database

2.1 Seismic data

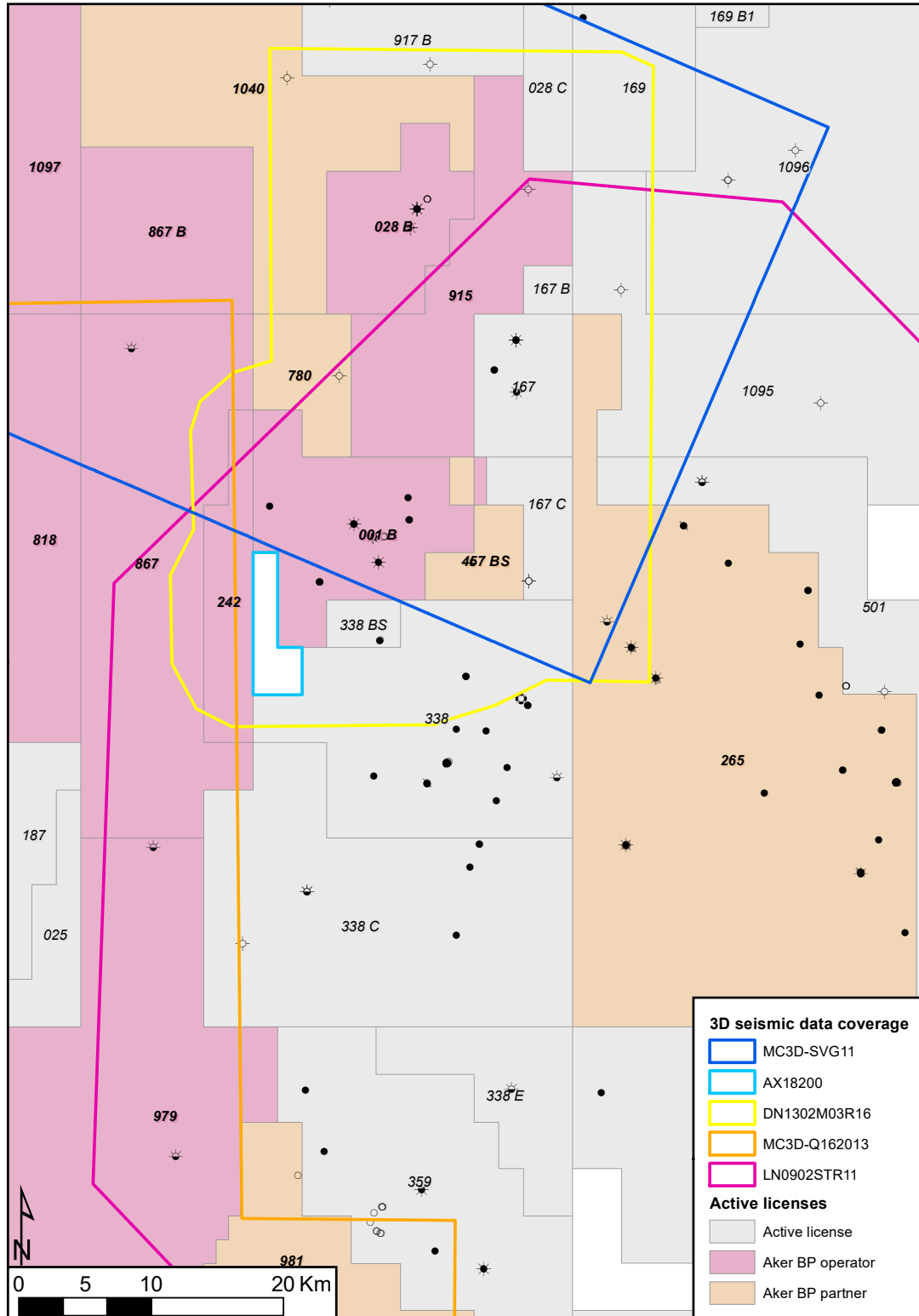


Fig. 2.1 Seismic database PL868 Licensed area PL868 shown in light blue outline.

In September 2013, 71 square km of Ocean Bottom Cable (OBC) seismic (DN1302) were acquired over the Ivar Aasen Field and part of the West Cable structure. The final processed OBC data was delivered by the end of 2014 and has been merged with reprocessed streamer data (LN0902 and MC3D-SVG11) to cover Ivar Aasen, West Cable and Hanz (Seismic survey DN1302M01). The merged data set formed the basis for interpreted faults and horizons in the 2016 application area. The same year, this survey was reprocessed by SGS, and became part of common database in 2017.

The license group also purchased the new available PGS reprocessed seismic dataset PGS16910VIK. Aker BP performed in-house conditioning and inversion on the data, completed August 2018

The AX18200 OBN data were acquired in 2018-2019, and the processing of the northern part of the survey was finished during the first quarter of 2020, and it was included in the common database. The AX18200 seismic data are currently the first and largest OBN survey targeted for exploration purposes in the North Sea, and is covering Aker BP's core area west of the Ivar Aasen Field, including the PL868. The operator and current partner in the license have access to the full survey, but the common database only covers the licensed area.

The OBN seismic data have several advantages compared to conventional streamer data, such as a larger fold, resulting in an improved signal to noise ratio. In addition, the full azimuth coverage of the OBN seismic data resulted in better imaging and definition of certain geological features, such as faults and steeply dipping features. The OBN seismic data also gave the possibility to analyse converted shear waves, which is an advantage in seismic reservoir characterization.

Table 2.1 Common seismic database *Common seismic database*

Name	Child surveys	Area (sqkm)	Company
AX18200		~7,1	TGS/AGS
PGS16910VIK	MC3D-Q162013	~627	PGS
DN1302M03R16	DN1302, LN0902, MC3D-SVG11	~425	Aker BP
MC3D-Q162013		314	PGS
MC3D-SVG11		219	PGS
LN0902STR11	LN0902	1650	Western Geco

2.2 Well Data

The wells defined in the common database are shown in Table 2.2 and Fig. 2.2.

Table 2.2 Common well database *Common well database*

Well	Year	Stratigraphy at TD	Status
15/3-1 S /ST2	1975	Middle Jurassic	Gas/Condensate
15/3-2 R	1977	Middle Jurassic	Shows
15/3-3	1979	Triassic	Gas/Condensate
15/3-4	1982	Triassic	Oil/Gas
15/3-5	1984	Middle Jurassic	Oil
15/3-8	2006	Late Jurassic	Oil/Gas
15/3-9 /T2	2010	Middle Jurassic	Oil/Gas
16/1-1	1967	Late Cretaceous	Oil shows
16/1-2	1976	Pre-Devonian	Shows
16/1-3	1982	Pre-Devonian	Oil shows
16/1-4	1993	Pre-Devonian	Gas/Condensate
16/1-5	1998	Pre-Devonian	Shows
16/1-5A	1998	Late Jurassic	Shows
16/1-6A	2003	Late Cretaceous	Dry
16/1-6S	2003	Paleocene	Oil/Gas
16/1-7	2004	Late Triassic	Oil
16/1-8	2007	Late Triassic	Oil
16/1-9	2008	Late Triassic	Oil/Gas
16/1-10	2009	Early Jurassic	Oil
16/1-11	2010	Late Triassic	Oil/Gas
16/1-11A	2010	Late Triassic	Oil/Gas
16/1-12	2009	Pre-Devonian	Oil
16/1-13	2010	Late Triassic	Oil
16/1-14	2010	Late Triassic	Oil
16/1-15	2011	Pre-Devonian	Oil
16/1-16	2012	Permian	Oil
16/1-16A	2013	Late Triassic	Oil
16/1-21A	2015	Late Triassic	Oil
16/1-21S	2015	Late Triassic	Oil
16/1-22A	2015	Late Triassic	Oil
16/1-22S	2015	Late Triassic	Oil
16/1-24	2015	Late Jurassic	Dry
16/1-26A	2016	Middle Jurassic	Dry
16/1-26S	2016	Late Triassic	Oil/Gas
16/2-5	2009	Basement	Oil/Gas
16/4-6S	2013	Late Triassic	Oil
16/4-9S	2015	Jurassic/Triassic	Oil
25/10-8	1997	Early Permian	Oil/Gas
25/10-8A	1997	Late Jurassic	Dry
25/10-12ST2	2015	Triassic	Dry

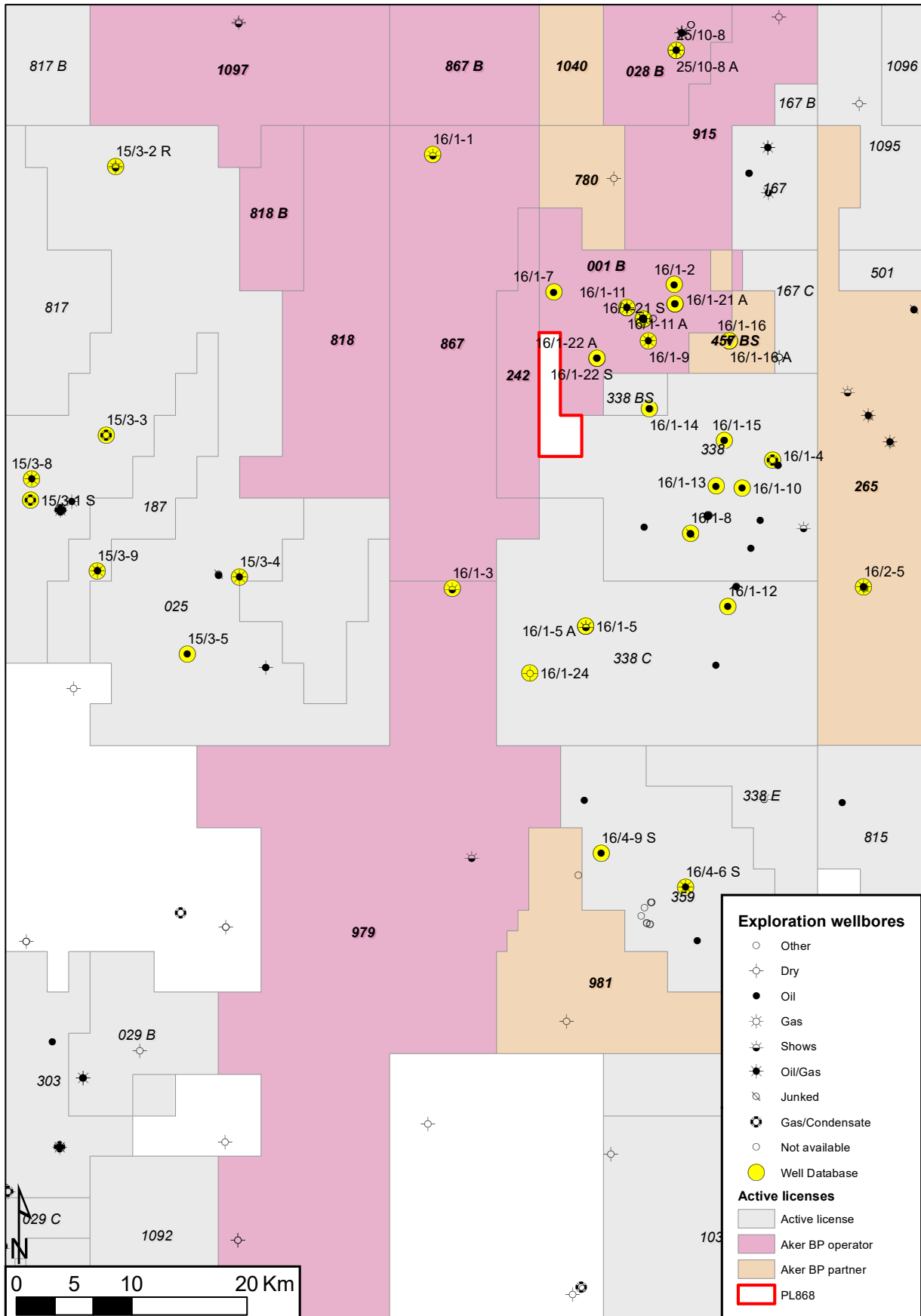


Fig. 2.2 Well database map Wells in common database outlined in yellow.

2.3 Special studies

Blueing of AX18200

The final AX18200 stacks received from the contractor were low frequency that resulted in poor vertical resolution. However, the data contained some good high frequency information. To utilize this, the high frequencies were boosted through an in-house blueing approach. The reflectivity of the earth possesses a "blue" frequency spectrum, i.e. more dominant high frequencies than low frequencies. During the blueing process, a blueing operator is calibrated to the reflectivity logs of central wells in the area to mimic the positive slope of their frequency spectrum. The corner frequencies of the operator are then adjusted to give the desired trade-off between increased resolution and low noise levels, before the operator is applied to the seismic data. As the frequency content in the AX18200 data varies greatly with depth, two different blueing volumes were created; one that targeted the Paleocene and one that targeted the deeper pre-Cretaceous seismic stratigraphy. The blueing process gave the desired uplift in terms of enhancing the vertical resolution and improving the reflections continuation

Seismic Data Conditioning AX 18200

Conditioning work on the AX18200 COV (Common Offset Vector) final gathers, after denoise and trim-statics, are currently being performed. The work consists of:

1. Residual de-noise in COV domain (edge- and coherency-enhancing anisotropic diffusion filter);
2. Azimuthal sectorization (conversion from X-offset/Y-offset COV domain to offset/azimuth COCA, common-offset-common-azimuth, domain);
3. Residual de-noise in COCA domain (see pt.1);
4. Spectral balancing in offset direction to allow for the use of a single operator when performing bandwidth extension;
5. Bandwidth extension to widen the usable data bandwidth by boosting high frequencies through matching to an analytical (Butterworth) wavelet. High cut-off tested up to 30 Hz;
6. Stacking each azimuth separately;
7. Q-compensation (amplitude only) to balance the amplitudes in depth; and
8. Optimal azimuthal stack (weighting different azimuthal stacks to highlight the geology that is more coherent in some azimuths and not in others).

Steps 1-5 were performed in pre-stack domain and the conditioned data can be further used to obtain AVAZ (Amplitude Variation with Azimuth) attribute volumes. Steps 6-7 are used to produce a set of azimuthal stacks to aid in interpretation of features that are influenced by difference in azimuthal illumination. Overall, the conditioning work benefits the resulting stacks in the intervals of interest and azimuthal stacks are useful in highlighting features being suppressed during full-gather stacking.

Geochemistry

Aker BP has a geochemical study that comprises 105 fluids from a large geographical area in the South Viking Graben for oil-oil and oil-source rock correlation. Most of the oils found surrounding PL868 license have a geochemical signature typical of the Draupne Formation and the most relevant fluids are from the Gudrun, Sigrun, West Cable, Ivar Aasen, Apollo, Edvard Grieg and Hanz. These fluids are all assigned to oil family C1 (upper Draupne Formation), while the Hanz

fluids shares similarities with oil family C2 (entire Draupne Formation) as defined in Justwan et al. (2006). Maturity parameters, i.e. Ts/Tm, C29Ts/C29Tm, mono- and tri-aromatic sterane ratios and position in both Sofer and Thompson plots, indicate that the fluids in Gudrun, Sigrun, West Cable and Ivar Aasen are late mature in character, while Edvard Grieg fluids have 'normal' maturity.

Fluid samples from different locations on the Ivar Aasen field is also included in this study, and the results points to a specific entry point of hydrocarbons to the producing field from the basin in the west. Together with a fresh fluid sample from the production well on the West Cable field, a migration pathway from the kitchen to the west, through West Cable and into Ivar Aasen is assumed from the results. These results have been incorporated into the overall understanding of the hydrocarbon system on the Gudrun Terrace, and the prospectivity in PL868 and the understanding of the prospect risks in particular.

Surface Geochemistry/Geomicrobiology

During summer 2017 Aker BP conducted a surface geochemistry/microbiology survey over an area from the Norwegian/UK border in the west to the western boundary of the Utsira High in the east, and from north of Gina Krog in the south to the Hanz Discovery in the north. The project was supported and co-financed by a number of other oil companies. The survey was performed by ORG Geophysical AS using a new developed Subsea Sampling Unit (SSU). This lander is equipped with direct hydrocarbon detectors (gas stripper-mass spectrometric detector, UV-VIS) and environmental sensors (pH, oxidation reduction potential [ORP], temperature, conductivity, dissolved oxygen [DO]). Direct hydrocarbon detection was complemented by the MPOG® (Microbial Prospecting for Oil and Gas) technique by MicroPro GmbH, Gommern, Germany. Headspace feeding experiments with methane and a mixture of wet gas/oil, respectively, were done to discover areas of enhanced microbiological activity in the top sediment layer. The concept of this direct hydrocarbon analysis method is based on the occurrence and effects of hydrocarbon micro seepage over petroleum reservoirs. The data collected consist of individual petroleum related hydrocarbon readings from methane (C₁) up to *n*-dodecane (*n*C₁₂), in situ environmental parameters (dissolved oxygen, redox potential, conductivity, temperature and pH), and total fluorescent hydrocarbons. Regional maps have been classified in terms of cluster areas with anomalous concentrations.

Several samples were taken on the sea floor directly overlaying the prospects and leads within the PL868 license area. The sample points have been classified in a scale according to hydrocarbon concentrations of each parameter (C1 to C10) in the final study report, designed to highlight 'true' anomalies, i.e sample points where concentration is significantly above the estimated method background. The observations above the PL868 prospectivity have been used as an positive/negative indicator of fluid filling in the Jurassic prospects, but is not used directly in de-risking of the prospects.

Fault zone validation and seal potential assessment

In 2018, Tim Budden, Principal Consultant Redwing Geoscience LLC, Structural Geoscience and Geomechanics, conducted a study of the fault seal capacity on the Stuttgongkampen -and the Nautgardstinden prospects. In-house structural framework and mapped surfaces was used in the study, and the results included;

- Structural framework review, addition of fault zone detail and modification of local fault zone geometry
- Scenario testing - Calculate and validate displacements on major faults
- Define juxtapositions and apply fault zone models, test lithological -and smear algorithm

sensitivities

- Define most-likely fault zone sealing characteristics for Stuttgonkampen, Nautgardstinden and 16/1-26S fault block

Further work have also been conducted in-house as an extension to this study. 1D analysis of sealing capacity of different lithologies drilled by nearby wells at varying fault displacements have been used as input (referred to as shale-gauge-ratios, "SGR"). Further, the SGR from the wells is used in an in-house program to predict the capacity to seal hydrocarbon column heights, based on the sealing capacity of the fault, expected fluid -and reservoir pressure. A large database of confirmed down-faulted traps and column heights, combined with seal capacity in relation to lithology, fault displacement, pressure and fluid buoyancy have been used to guide the column heights -and risks in the evaluation of the PL868 prospectivity.

3 Remaining prospectivity

Processing of the AX18200 survey was finished during the first quarter of 2020. Extensive in-house geophysical work has been carried out on the entire AX18200 dataset. This includes de-noising, spectral balancing and variable time adjustment of every angle stack to optimize for AVO work. Coloured inversion and EEI cubes (Intercept vs Gradient rotations) resulting in lithology and fluid cubes are also produced.

Geochemistry and regional understanding of the petroleum system have been part of the license work, as migration was identified as high risk on the Nautgardstinden prospect. In addition, an extensive work has been done to understand the risk contained in a down-faulted trap, its ability to trap hydrocarbons and expected column height.

Three prospects have been evaluated within the license: Stuttgongkampen (Vestland gr.) (Fig. 3.2), Nautgardstinden (Vestland gr.) and Styggehøye (Viking gr.) (Fig. 3.1). Stuttgongkampen lies in a favourable position to receive HCs from the main kitchen area, but the prospect was degraded due to the 16/1-26A well, which delineates the upside of the OWC. A regional geochemical analysis of hydrocarbons also suggests a migration path going through the down-faulted block, from the kitchen area towards the Ivar Aasen field. Together with negative fault seal analysis, the licenses assessed the prospect to have low chance of a competent trap.

The Nautgardstinden and Styggehøye prospects are also defined as down-faulted traps, and fault seal analysis on relevant wells prove a better chance of competent trap. The two prospects could also be tested with a single well and was regarded as the main prospects by the license. However, Nautgardstinden is mapped to lie in a migration shadow, and volume assessment of both reservoirs show a structural apex outside licensed area; both are dependent on hydrocarbon columns exceeding 100m to prove value within the license. In-house studies gives a low chance of accumulating high columns in this particular down-faulted trap. The combination of high risk to seal of high hydrocarbon columns and the low chance of migration was regarded by the license as too high risk for a positive drill decision.

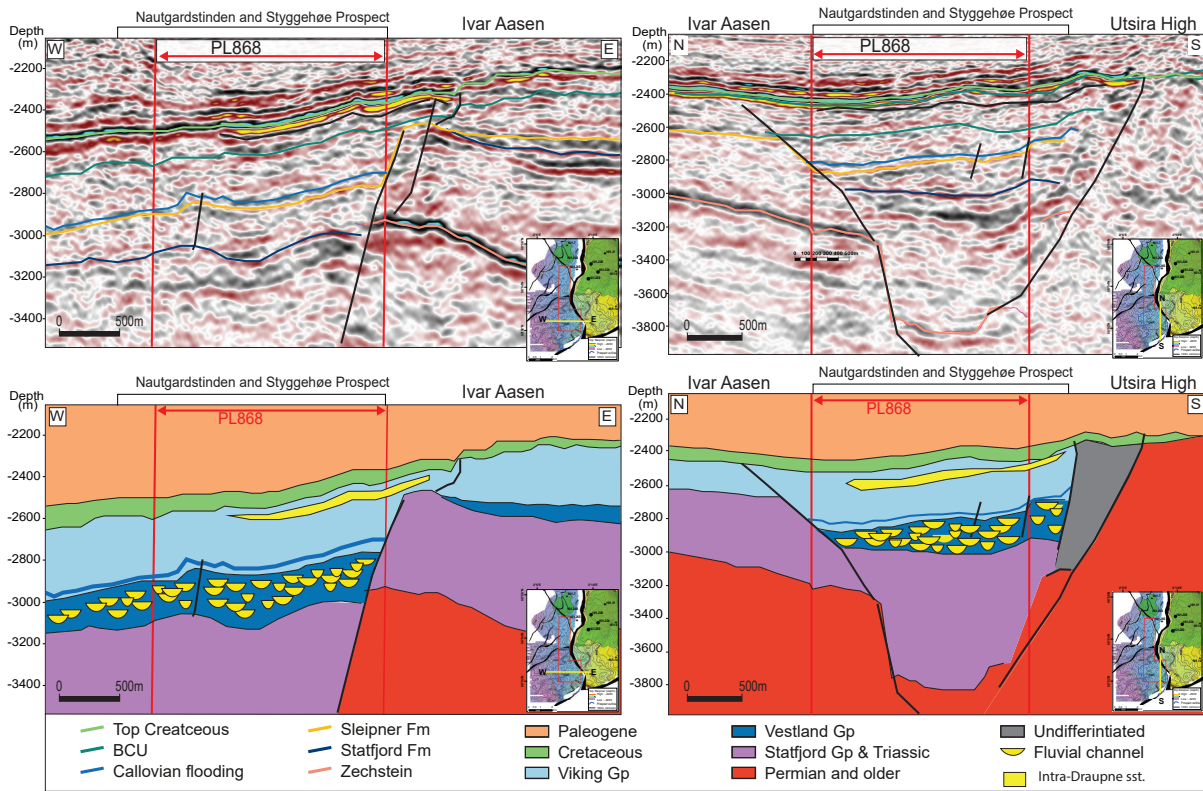


Fig. 3.1 Seismic and geoseismic profiles through the Nautgardstinden Prospect. The Nautgardstinden Prospect is defined in the Vestland Group. The extent of the prospect is indicated by the yellow arrows.

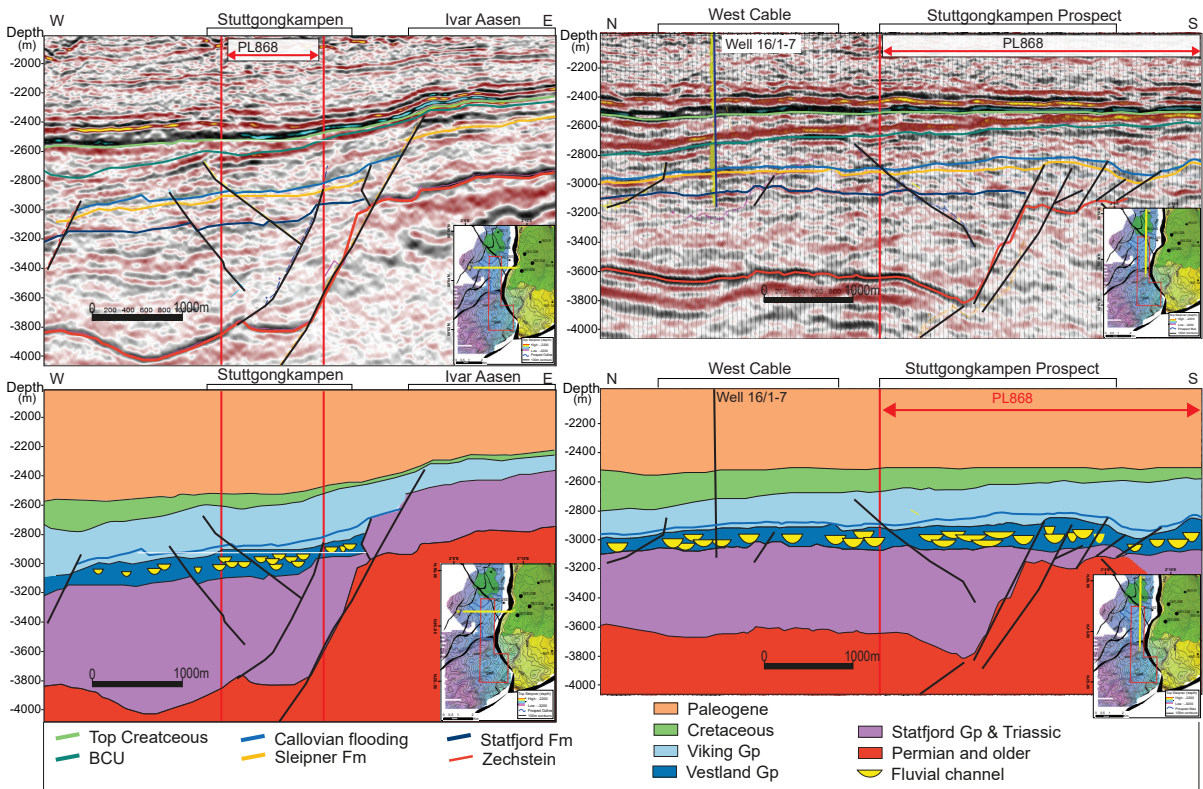


Fig. 3.2 Seismic and geoseismic profiles for the Stuttgongkampen Prospect. The Stuttgongkampen Prospect is defined in the Vestland Group. The extent of the prospect is indicated by the yellow arrow.

4 Conclusion

The three prospects evaluated in the license, Stuttgongkampen, Nautgardstinden and Stygghøe, all have significant risk on seal and/or migration. Prospect volumes inside the license are not considered large enough to support a positive drill decision for PL868. Hence the JV decided to drop the license. The license work program has been completed.

5 References

Application for extension of deadlines 06.12.2018 (SMIL ref. ABP -2018-12)

Approval from MPE 04.04.2019 (MPE ref. 18/2107-3)

Application for extension of deadlines 19.06.2020 (SMIL ref. ABP -2020-14)

Approval from MPE 02.07.2020 (MPE ref. 18/2107-6)

Notification to drop license 05.02.2021 (SMIL ref. 2021-10)

Approval of relinquishment from MPE 02.03.2021 (MPE ref. 21/303-3)



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