Title Report

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wintershall

SURRENDER REPORT

PL 678 S/ BS/ C/ SB

MOL

Lundin
Norway

fortis
petroleum

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1 Key License History

Production License 678 S was awarded in APA 2012 to Wintershall Norge AS (operator, 35%), Det norske oljeseskap AS (25%), Lundin Norway AS (20%) and Fortis Petroleum Norway AS (20%) and became effective on 08.02.2013. DoD was 08.02.2015, BoK was 08.02.2017 and the license was valid until 08.02.2021. As of 01.01.2016 MOL Norge AS took over the 25% license share from Det norske oljeselskap.

The license area of PL 678S in located in part of blocks 26/1, 26/2, 26/4 and 31/10 (see Fig. 1.1) and included a total area of 1204 km². The license area is partly stratigraphic. The main prospects are Firebird and Phoenix, which are both defined at the middle Jurassic Brent Gp level. The initial work commitment included reprocessing of existing 3D seismic resulting in the survey WIN14M02, and G&G studies.

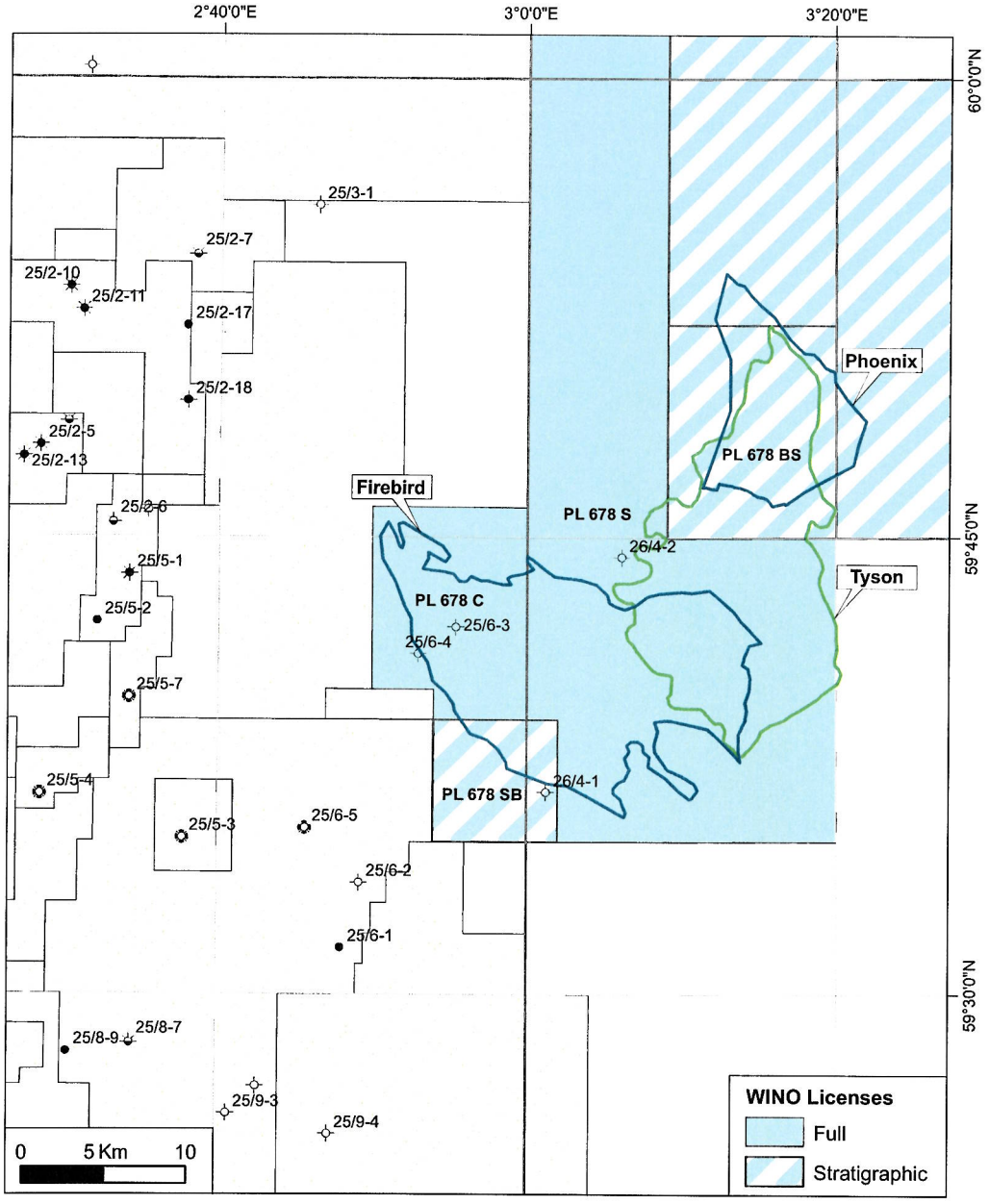

Fig. 1.1 Location map
PL 678S/BS/C/SB with prospect outlines

In APA 2013 the license area extension PL678 BS, located in part of blocks 26/1, was awarded, with an area of 134 km². The target for this extension was the Paleocene Tyson prospect, which was partly located outside of the PL 678S area. The license phases and work commitment for PL 678 BS was the same as for PL 678S.

In APA 2014 the license area extension PL 678 C, located in part of blocks 25/3 and 25/6, was awarded, with an area of 115 km². The aim of this area extension was to capture the western part of the Firebird prospect in acreage that had become available. The license phases and work commitment for PL 678 C was the same as for PL 678S, but in phase 2 "drilling an exploration well", the well had to be drilled on the prospect applied for.

In APA 2015 the license area extension PL 678 SB, located in blocks 25/6 and 26/4, was awarded, with an area of 56 km². The aim of this area extension was to capture the western part of the Firebird prospect in acreage that had become available. The license phases and work commitment for PL 678 SB was the same as for PL 678S, but in phase 2 "drilling an exploration well", the well had to be drilled on the prospect applied for.

An application for a one-year time extension was granted in December 2014 in order to allow time for interpretation of the reprocessed seismic WIN14M02.

An application for a one-year time extension was granted in February 2016 to allow time to preform a sea-bottom micro-seepage study for geochemistry and microbial activity. The purpose of this study was to further evaluate the prospectivity of the area in order to make the Drill-or-drop decision.

The Firebird prospect is located in blocks 25/3, 25/6 and 26/4 of the North Sea. The large prospect relies on the proven and prolific Middle Jurassic sandstone Play Model. The prospect is located approximately 20 Km east of Frøy Field and 15 Km east of the Skirne Facility and lie in 130 m of water. Top reservoir is at 2750 m MSL. The Firebird prospect is a faulted hangingwall block defined at the Top Brent Gp. level. Middle Jurassic shallow marine sandstones of the Ness and Tarbert formations are the main reservoir targets. A secondary target is represented by the Triassic - Lower Jurassic fluviatile sandstones of the Statfjord Formation. Top Seal is the Upper Jurassic shales of the Heather and Draupne formations. The main geological risk for this prospect is assessed to be lateral seal.

The Phoenix prospect is a faulted horst block defined on the Top Brent Gp. level. Middle Jurassic shallow marine sandstones of the Ness and Tarbert formations are the main reservoir targets. A secondary target is represented by the Triassic - Lower Jurassic fluviatile sandstones of the Statfjord Formation. Top Seal is the Upper Jurassic shales of the Heather and Draupne formations. The main geological risk for this prospect is assessed to be hydrocarbon charge.

Charge for both prospects are from the regionally present organic-rich shales of the Draupne Formation and likely migrated from a mature westerly kitchen. The Phoenix prospect may also receive charge at the Statfjord Fm. level from a local Statfjord source, however the quality and maturity of a Statfjord source accross the license area is uncertain.

Results of the micro-seepage study did not resolve the trap risk for the Firebird prospect or the charge risk for the Phoenix prospect. The volume potential for the Phoenix prospect is also considered too small for a stand-alone development. The Tyson prospect has a high risk on reservoir presence and is considered a secondary target. Wintershall Norge AS has therefore proposed to fully surrender this Production License in 2017. This proposal has been endorsed by the majority of the partners in the license.

All four parts of PL678 (S/BS/C/SB) have been combined in one license with common EC and MC committees. The meetings held in PL 678S/BS/C/SB is summarized in Table 1.1.

Meetings	Date
Kick-off Meeting	09.04.2013
EC/MC: Reprocessing of seismic - status, basin modelling results, 2014 budget and work program	21.11.2013
EC: Work meeting, design of geochemical study	13.02.2014
EC: WIN14M02 reprocessing, status geochemistry study, status fault seal analysis	22.05.2014
EC/MC: geochemistry study results, fault seal analysis and basin modelling results, license time extension, 2015 budget and work program	19.11.2014
EC: volumes and risking	21.04.2015
EC: discussion on geochemistry and hydrocarbon migration	08.05.2015
EC/MC: application for license time extension for seabottom micro-seepage sampling, 2016 budget and work program	04.11.2015
EC/MC: license status/strategy discussion	15.01.2016
EC: planning of seabottom micro-seepage sampling survey	27.04.2016
EC/MC: Summary of seabottom micro-seepage study, Drill-or-Drop decision	08.12.2016

2 Database

2.1 Seismic data

Several 2D and 3D seismic surveys were used in the initial mapping of the Firebird and Phoenix prospects as outlined in the APA 2012 application submitted by Wintershall and Lundin. As part of the work program for PL 678S/BS/C/SB, the 3D surveys UH98 and EN0101 have been reprocessed and merged into the new 3D data set WIN14M02. The reprocessing has removed the differences in polarity and amplitudes as well as the TWT mismatch seen between the two original surveys. The data quality in general has also been improved. The 3D seismic data set WIN14M02 has been used in the detailed prospect evaluations.

The areal extent of the reprocessed seismic WIN14M02 is 1570 km² and is outlined in yellow in Fig. 2.1. The Firebird, Phoenix and Tyson prospects lies within the extent of WIN14M02.

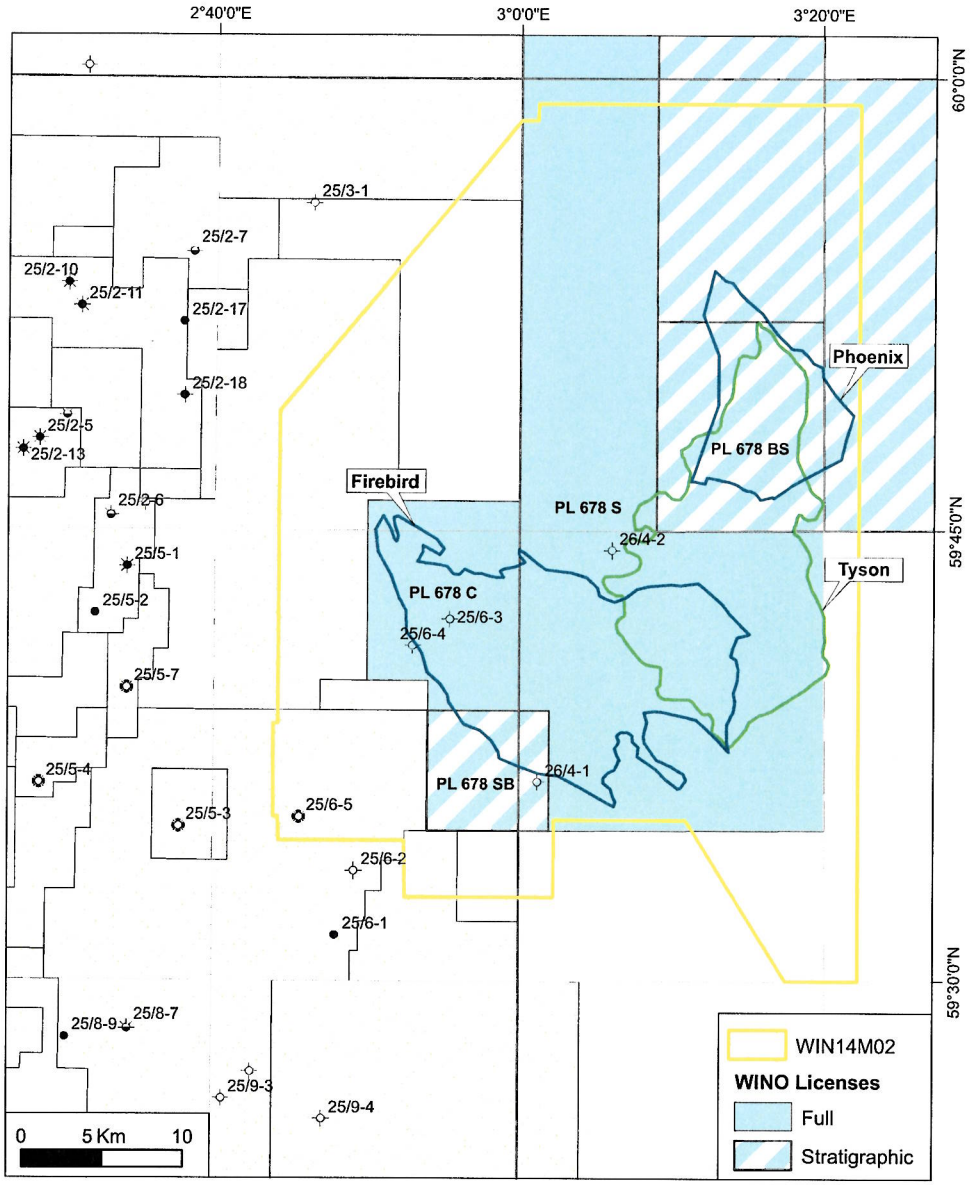

Fig. 2.1 Outline of reprocessed seismic
The extent of the reprocessed seismic WIN14M02 is shown in yellow. The area applied for is shown by the red polygon, while the Firebird prospect is outlined in violet.

Table 2.1 PL 734 Seismic Database

Seismic Survey Name	NPDID	Category
WIN14M02	--	Reprocess/Merge - Owned by license group

2.2 Well data

Twelve relevant wells penetrating the Triassic and Jurassic sequences (and with available wireline log data) compose the CPI database for PL 678S/BS/C/SB. The wells included in the well database are listed in Table 2.2. The well locations are shown in Fig. 2.2. Key wells are 26/4-1 and 25/6-4S since these wells are the Brent penetrations closest to the Firebird and Phoenix prospects.

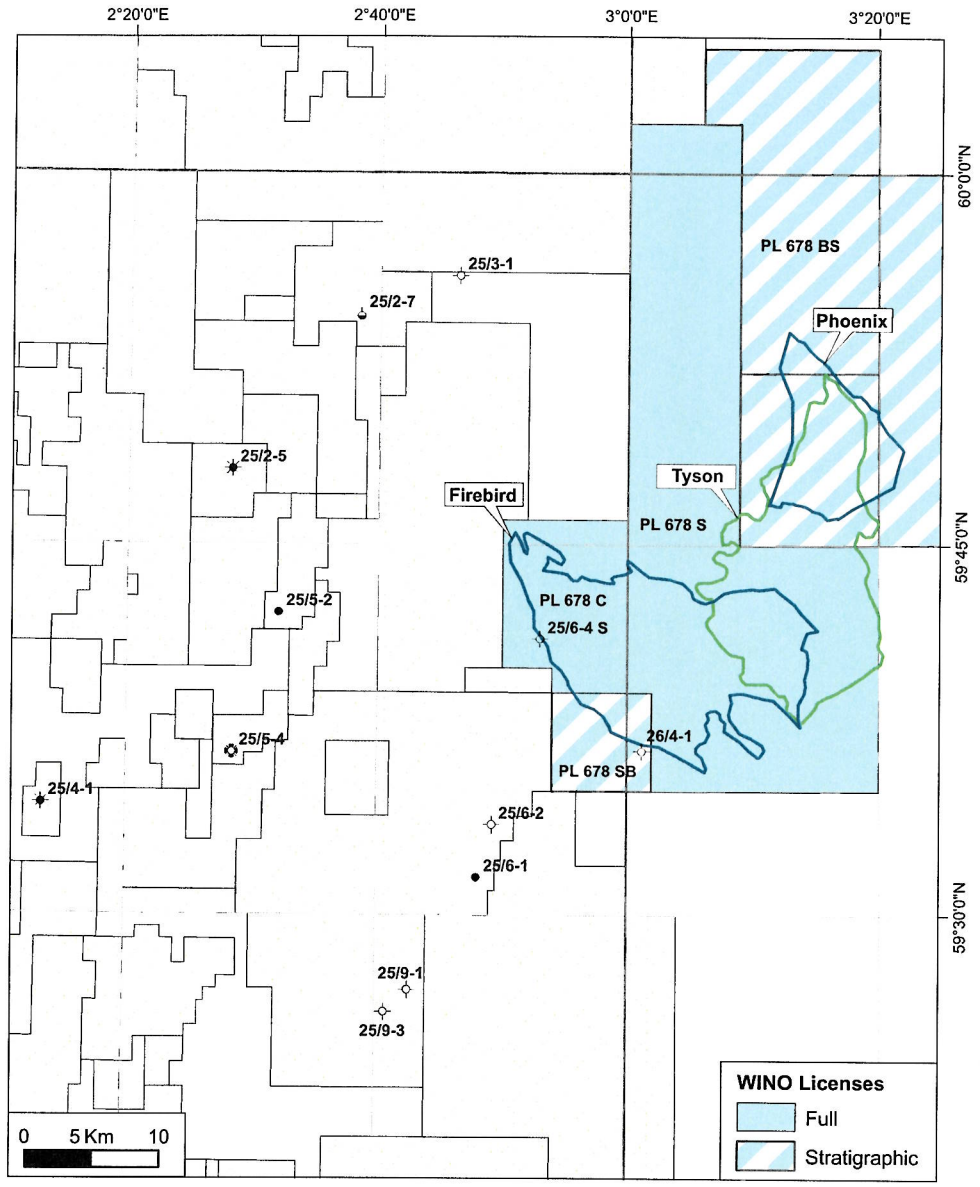

Fig. 2.2 Well database
The wells included in the database are 25/2-5, 25/2-7, 25/3-1, 25/4-1, 25/5-2, 25/5-4, 25/6-1, 25/6-2, 25/6-4S, 25/9-1, 25/9-3, 26/4-1.

Table 2.2 PL 678S/BS/C/SB Well Database

Well Name	NPDID
25/2-5	357
25/2-7	47
25/3-1	1419
25/4-1	359
25/5-2	1346
25/5-4	1691
25/6-1	524
25/6-2	1949
25/6-4S	6507
25/9-1	2476
25/9-3	6189
26/4-1	1046

2.3 Special studies

In addition to seismic interpretation and CPI analysis of well logs, a geochemical study, fault seal analysis, basin modelling study and a sea-bottom microseepage sampling study were carried out in order to evaluate the hydrocarbon potential of the acreage. Studies are listed in Table 2.3.

Table 2.3 Special Studies in PL 678S

Study	Author	Date
Geochemistry study	APT	November 2014
Fault seal analysis	Wintershall	November 2014
Basin modelling study	Wintershall	November 2014
Sea-bottom microseepage study	AGI / Micropro	December 2016

3 Review of Geological and Geophysical studies

Geological Background

PL 678S/BS/C/SB is located at the northern tip of the Utsira High, on the eastern flank of the Viking Graben. The Stord Basin is located east of the license. The North Sea rift system has experienced a prolonged extensional history starting in Devonian times (The Millennium Atlas, 2003). The main rift phases occurred in Permo-Triassic and MIddle Jurassic to Early Cretaceous times. The North Sea rift is a triple system with arms forming the Viking Graben, the Central Graben and the Moray Firth basins. The tripple-junction between the arms was located west of the Jæren High during Callovian times.

Major crustal lineaments were produced by Early Devonian and earlier Caledonian deformation (Bartholomew et al, 1993; Kimbell et al, 2005). Rifting of Devonian and Carboniferous age were typically associated with large strike-slip faults, also involving pre-existing lineaments. The Permo-Triassic extension in the Viking Graben had a North-South trending rift axis located mainly in the Stord Basin and the Horda Platform. During the Middle Jurassic times thermal doming and uplift of the tripple-junction caused erosion of Triassic and Early Jurassic sediments. Erosional products were redeposited in deltaic complexes such as the Brent delta, forming the commercially important Middle Jurassic reservoirs in the Viking Graben. Cooling and thermal subsidence of the dome and rifts during Late Jurassic times caused deposition of the marine Heather and Draupne shales which are the important source rocks in the area.

Hydrocarbon Prospectivity

The prospects Firebird and Phoenix relies on the proven and prolific Middle Jurassic sandstone Play Model. The prospect is located approximately 20 Km east of Frøy Field and 15 Km east of the Skirne Facility and the water depth is 105-190 m. Top reservoir is at 2770 (Firebird) and 2935 (Phoenix) m MSL.

The Firebird prospect is a faulted hangingwall block defined at the Top Brent Group level. The main bounding fault is created by dip-slip and strike-slip reactivation of pre-existing basement lineaments. Middle Jurassic shallow marine sandstones of the Ness and Tarbert formations are the main reservoir targets. A secondary target is represented by the Triassic - Lower Jurassic fluviatile sandstones of the Statfjord Formation. Top Seal is the Upper Jurassic shales of the Heather and Draupne formations. The main geological risk for this prospect is assessed to be lateral seal.

The Phoenix prospect is a faulted horst also defined at the Top Brent Group level. Middle Jurassic shallow marine sandstones of the Ness and Tarbert formations are the main reservoir targets. A secondary target is represented by the Triassic - Lower Jurassic fluviatile sandstones of the Statfjord Formation. Top Seal is the Upper Jurassic shales of the Heather and Draupne formations and of the Dunlin Formation respectively. The main geologic risk is assessed to be hydrocarbon charge.

Charge for both prospects will be from the regionally present organic-rich shales of the Draupne and Heather Formations and likely migrated from a mature westerly kitchen in the Viking Graben. The Phoenix prospect may also receive charge from a local Statfjord source rock given that this source is present and has reached sufficient maturity within the local drainage area of the Phoenix prospect.

Geological and Geophysical Studies

Geochemistry

An extensive geochemistry study was performed including sampling and analysis of 70 samples of cuttings and cores from 13 wells in the area close to PL 678S/BS/C/SB. This new data set has been analysed together with existing data to investigate oil-source correlations in the area and also to study the source rock properties of the intra-Statfjord source intervalls in detail.

The results of the analysis are that shows and discoveries in the area may more likely be sourced from the Heather Fm source than the Draupne Fm source rock. Also, data from the Statfjord Fm, in particular from well 26/4-1, show that the intra-Statfjord source rock can have moderate to good source rock properties and may act as an important source rock locally.

Fault Seal Analysis, Firebird Prospect

A fault seal study has been performed by Wintershall to analyse the sealing potential of the main bounding fault in the Firebird prospect. A clay smear model has been used to estimate the maximum oil column height that the fault can hold. The column height estimates have been further used in the calculation of the most likely volumes accumulated in the prospect. The Firebird bounding fault is part of a large scale NW-SE trending strike-slip fault. Enhanced cataclasis and diagenesis due to the strike-slip movement may increase the sealing properties further. However, a reliable prediction of additional sealing potential due to strike-slip movement is not possible to give and has not been included in the fault seal analysis. The Phoenix prospect is an up-thrown horst block with limited fault seal risk as the structural spill point above any reservoir-reservoir juxtaposition.

Capillary Fault Seal Analysis

The Capillary Fault Seal Analysis is based on the concept of Shale Gouge Ratio (SGR). In the SGR calculations we have used Vshale logs from 25/6-4S and 26/4-1. The fault seal analysis shows that the highest risk of capillary fault seal failure is expected in the section of the fault close to the well 25/6-4S. The SGR values modelled along the Firebird bounding fault are shown in Fig. 3.1 (fault section close to the well 25/6-4S). The critical sand-on-sand windows modelled along the trap bounding faults show SGR value ranges of 15-50 %. Using the SGR parameter as a proxy for the clay content of the fault rock this could indicate that along these faults a small to medium potential capillary seal is likely to occur for a potentially present oil phase trapped in the Firebird area. Using the published regional to global calibration function of Yielding et al (2010), where the regression is based on real North Sea data, the SGR values can be related to hydrocarbon column heights that can be trapped. The fault seal modelling gives an expected oil-water contact at 2830m, and a hydrocarbon column height of ca. 110 m. Here we have used fluid densities of 700 kg/cm3 for oil and 1027 kg/m3 for water. This analysis indicates that although there are intervals of reservoir-reservoir juxtapositions there may be an effective capillary membrane seal acting as static capillary seals for hydrocarbons trapped in Firebird.

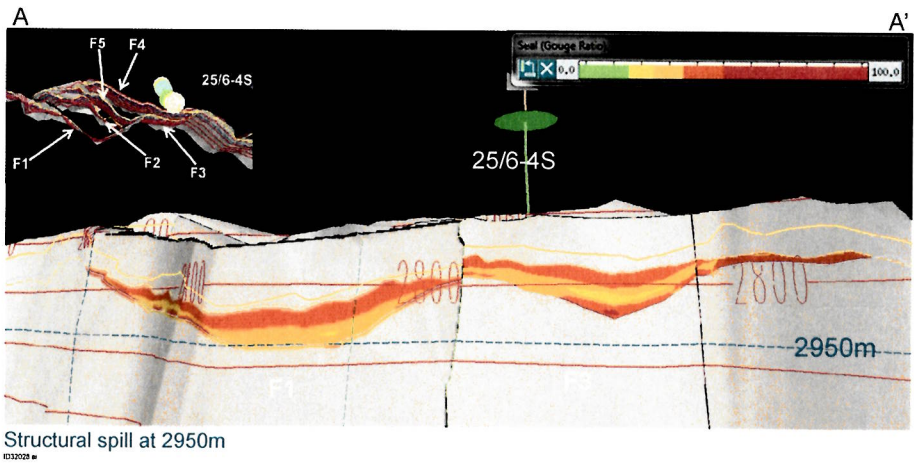

Fig. 3.1 Firebird fault - SGR values.
Fault section close to the well 25/6-4S as indicated by the points A and A' in Fig. 2.4. SGR values are in the range 15-50%.

Relay Ramp

A special focus in the Fault Seal Analysis has been put on the relay ramp structure close to well 26/4-1. A relay structure may in general be open to fluid flow since the fault segments making the relay ramp may not be connected. To assess the sealing potential of this part of the Firebird bounding fault, a standard juxtaposition/clay smear methodology is not feasible. We have rather looked at seismic attributes that can be evaluated in available software tools (Edge detection (Petrel), Ant tracking (Petrel), SOSemblance (Geoteric)). These attributes identifies structural breaks in 3D seismic volumes and can help identify small-scale faults. An example is shown in Fig. 3.2 displaying the Edge detection attribute (RDR plug-in in Petrel). Red/black colours represent structural breaks in the seismic data. The main NW-SE trending fault segments of the relay ramp can easily be identified. We also see NS trending faults cross-cutting the relay ramp. In addition the interior part of the relay ramp seems to be broken up and have a complex structure. This may further enhance cataclasis and diagenesis within the relay ramp as the depth and temperature are sufficient for quartz cementation to take place. A quantitative analysis of fault sealing properties of the relay-ramp is not possible. Instead we have included the risk of a leaking relay ramp in the probabilistic resource estimates.

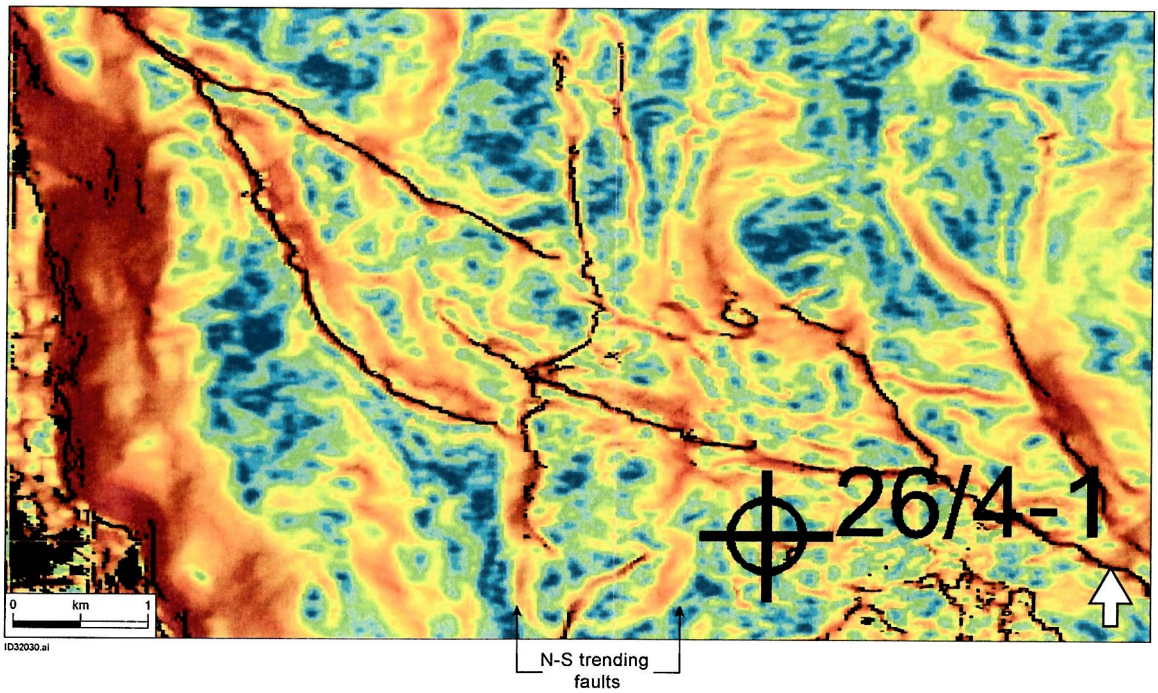

Fig. 3.2 Relay Ramp close to the well 26/4-1.
Edge detection attribute showing complex fault pattern close to the well 26/4-1. The areal extent of the map is indicated by the red dashed rectangle in Fig. 2.4. N-S trending faults cross-cutting the main Firebird fault are indicated by arrows.

Basin modelling study

To assess the charge history for the Firebird and Phoenix prospects, a basin modelling study has been carried out by Wintershall Norge AS as part of the license work in PL678S/BS/C/SB. The study includes analysis of source rock maturation, hydrocarbon migration and entrapment.

In the basin modelling results shown here we assume that the active source rocks are the Draupne and Heather Fms. Source rocks are mature in the Viking Graben, becoming less mature towards the east. The generated and expelled hydrocarbons will migrate along the Brent carrier unit. Modelling results are shown in Fig. 3.3. The drainage area of the Firebird

prospect is shown with a yellow outline. The drainage area extends towards the deeper part of the basin, demonstrating possible migration path ways from the mature source rocks and eastwards into the Firebird prospect. In this example we assume that the faults bounding the Firebird prospect to the west and south are sealing. The hydrocarbon volumes that are generated and migrated are sufficient to fill the trap to its structural spill point. The fluid phase expected in the prospect is oil. As also can be seen in Fig. 3.3 is that the Phoenix prospect will receive only a limited charge from the Drapune and Heather source rocks in the Viking Graben, demonstrating the charge risk for the Phoenix prospect. Separate basin modelling performed in the Statfjord reservoir unit and modelling charge from an intra-Statfjord source rock shows that the Phoenix prospect may receive charge within the Statfjord play, given that the intra-Statfjord source rock is present and is of sufficient maturity locally next to the Phoenix prospect.

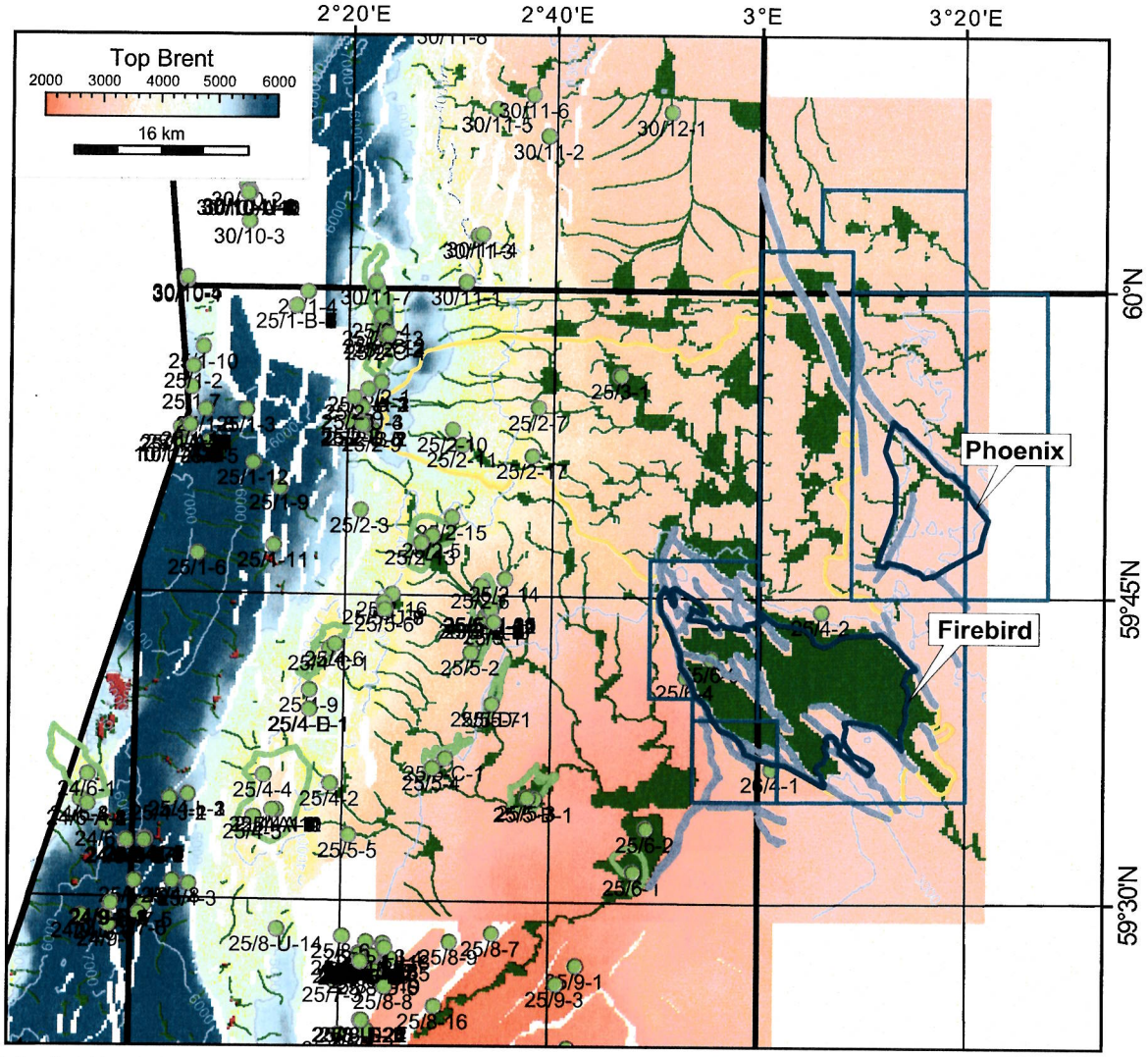

Fig. 3.3 Basin Modelling
Top Brent depth map, showing also hydrocarbon migration on Top Brent level. Green areas are oil accumulations. Hydrocarbon migration path ways are shown as green lines. The Firebird prospect is shown with a dark blue outline.The yellow polygon is the drainage area for the Firebird prospect.

Sea-bottom microseepage study

A sea-bottom sampling survey was undertaken during the summer of 2016 to look for geochemical and microbial anomalies across the license area. Such anomalies can indicate hydrocarbon accumulations. A total of 136 sea-bottom cores were taken from 133 different locations. From each core, sediment samples were taken for geochemical analysis and microbial analysis. The wells 25/2-5 (Lille-Frøy, oil/gas), 25/6-5S (Skirne East, gas condensate), 25/6-4S (dry) and 26/4-1 (dry) were used as calibration wells. The geochemical analysis measured all hydrocarbon compounds from C2-C20 and used statistical methods to identify compositions that would be anomalous and may indicate hydrocarbon accumulations. The microbial study investigated the microbial activity of live microbs feeding on hydrocarbons present in the samples. These living microbes would be dependent on continuous supply of hydrocarbons just below the sea bottom to survive, suggesting an active hydrocarbon system. Results from the microseepage study are summarized in Fig. 3.4. The calibration wells 25/2-5 and 25/6-5S show high readings of the lighter hydrocarbons. The lighter hydrocarbons are also seen in parts of the Firebird prospect. The Phoenix prospect is more dominated by heavier hydrocarbon compounds, heavier compounds are also seen in some locations west of Phoenix. Strong microbial activity is seen over most of the area except the south-eastern part of the Firebird prospect. Also areas outside the mapped prospects show high microbial readings, this effect is currently not fully understood. Taking the geochemical and microbial analysis together, the results seem to indicate migrating hydrocarbons in the area. However, as the anomalies do not cluster only within the prospect outlines, significant prospect risk still remains.

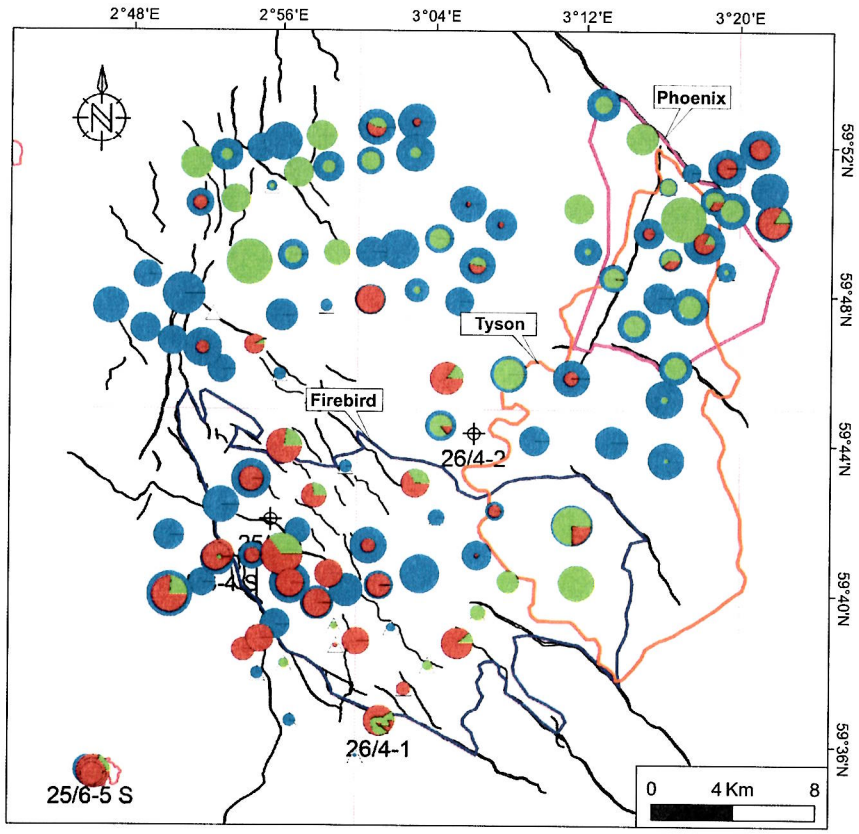

Fig. 3.4 Microseepage results.
Geochemical results are shown in red (light hydrocarbons) and light green (heavy hydrocarbon compounds). Microbial activity is shown in blue. Sizes of the discs shows the magnitude of the anomalies. Coring locations are shown by open triangles. The well 25/2-5 (outside of map area) show high readings of light hydrocarbons and high microbial activity.

4 Prospect Update report

In the 2012 APA Application, two prospects were identified and assessed, the Firebird and Phoenix prospects. Main targets for both prospects were the Middle Jurassic shallow marine sandstones of the Vestland Group (Tarbert and Ness formations). A secondary target is represented by the Triassic - Lower Jurassic fluviatile sandstones of the Statfjord Formation. Both prospects are fault-related structures. Firebird is located within the hangingwall block and relies on good fault seal properties for the trap to work. Phoenix is an up-faulted horst where fault seal is only a minor risk, but where hydrocarbon charge is the main risk.

All main horizons including the Top Brent have been reinterpreted using the reprocessed seismic WIN14M02. This improved the interpretation of both horizons and faults. The Firebird prospect is shown on the Top Brent Gp depth map in Fig. 4.1. A cross section through the Firebird prospect is shown in Fig. 4.2. The Phoenix prospect is shown on the Top Brent Gp map in Fig. 4.3 and a cross section throught the Phoenix prospect is shown in Fig. 4.4.

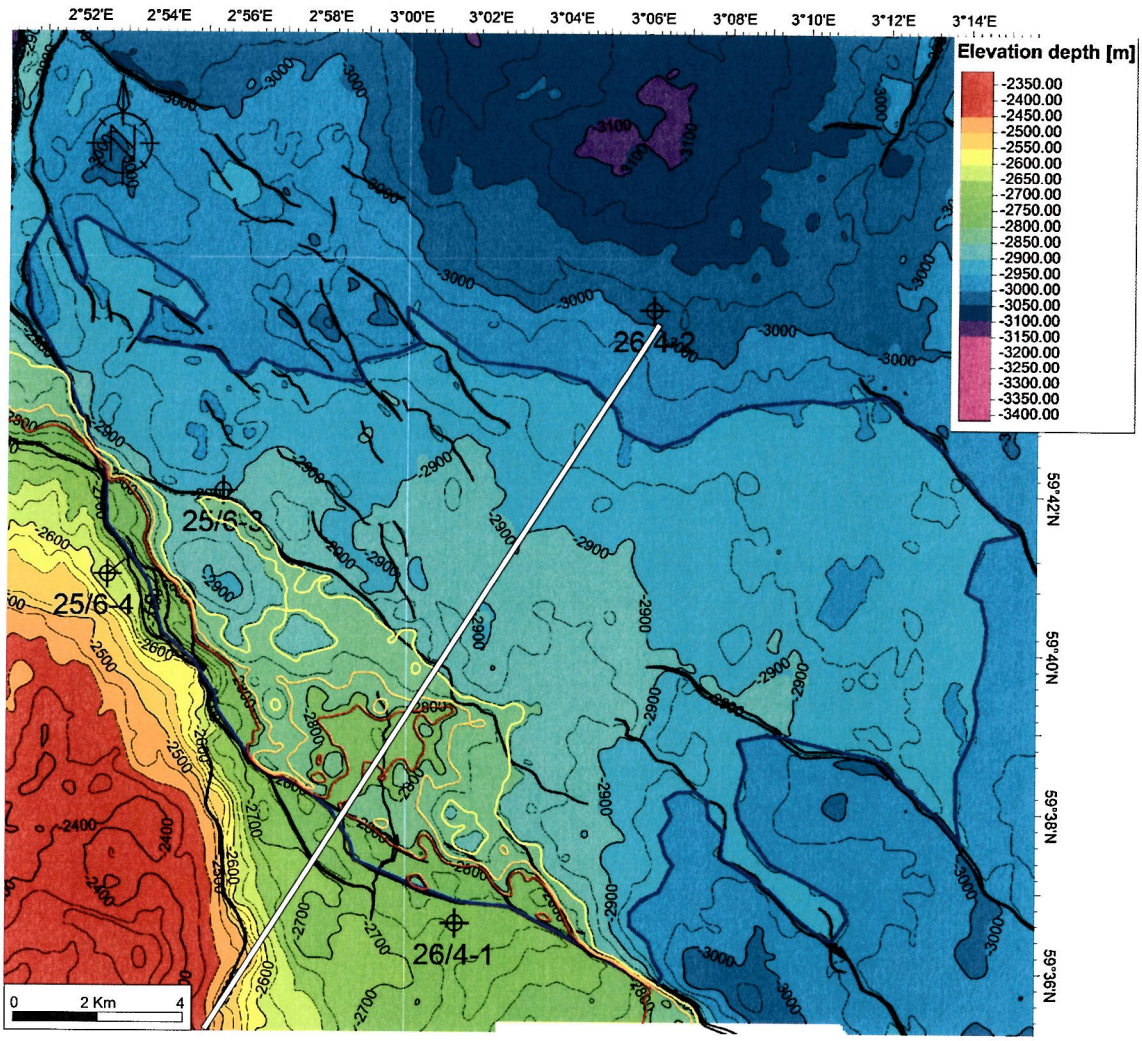

Fig. 4.1 Firebird prospect
Top Brent Gp depth map with polygon outline of the Firebird prospect. The following hydrocarbon-water contacts (in meters) are included: P90=2795 (red), P50=2812 (orange), P10=2845 (yellow)

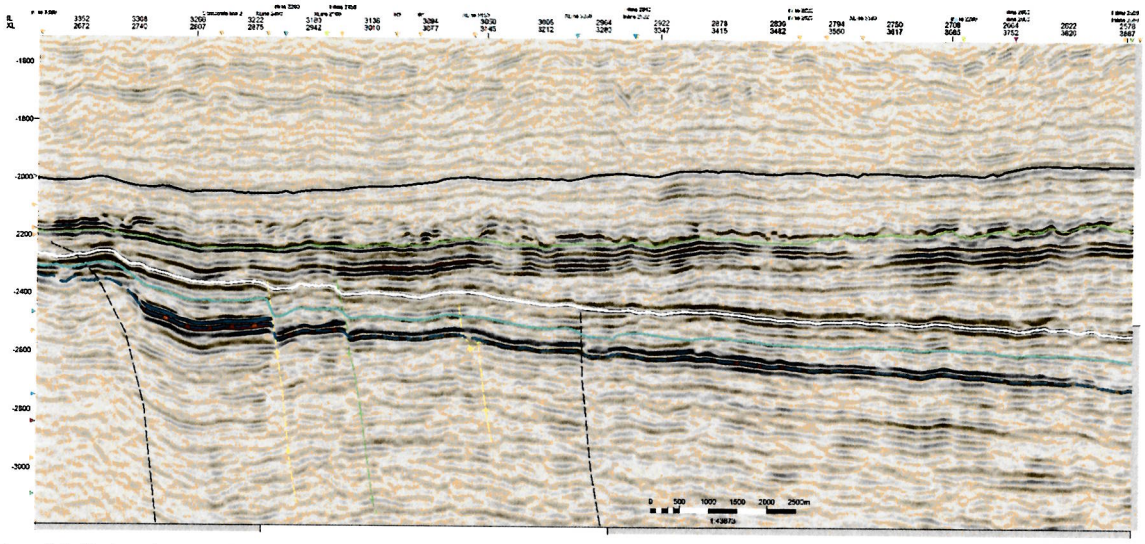

Fig. 4.2 Seismic section throught the Firebird prospect.
The following horizons are included: Top Balder Fm (black), Top Shetland Fm (green), BCU (white), Top Brent Gp (light blue), Top Dunlin Gp (dark blue stippled).

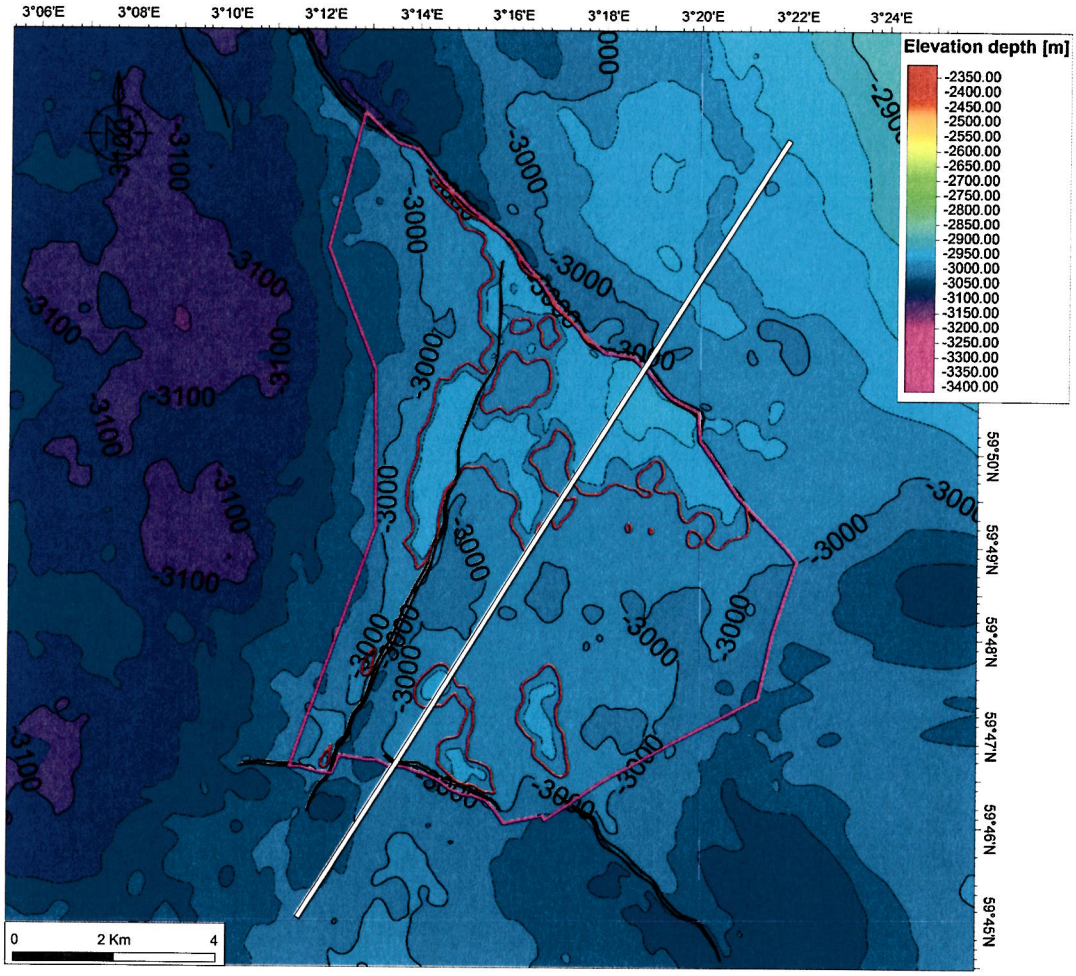

Fig. 4.3 Phoenix prospect
Top Brent Gp depth map with polygon outline of the Phoenix prospect. The lowest closing contour at 2980m is shown in red.

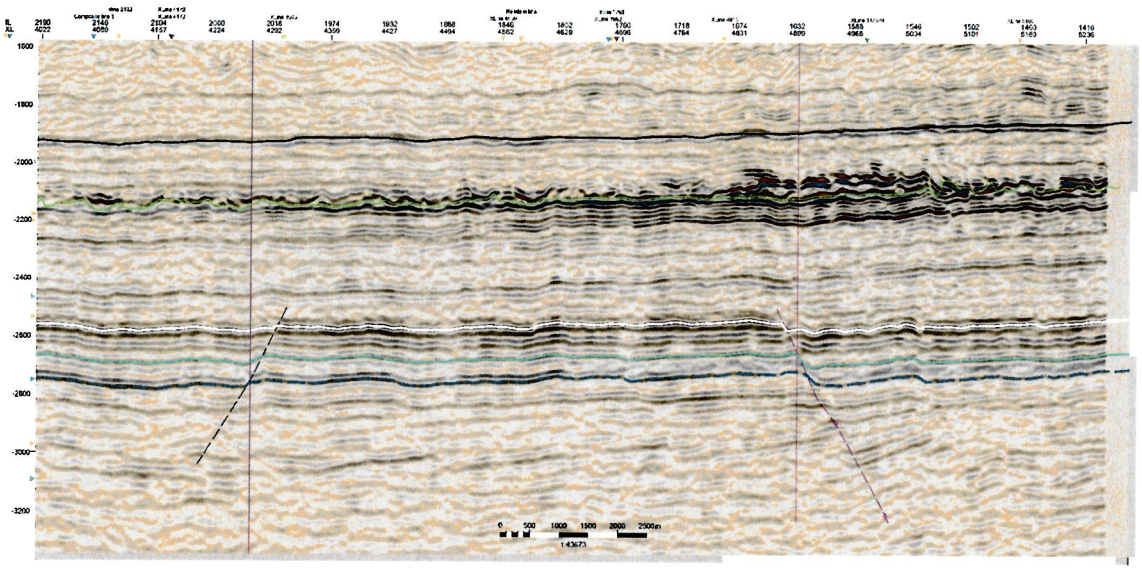

Fig. 4.4 Seismic section through the Phoenix prospect.
The following horizons are included: Top Balder Fm (black), Top Shetland Fm (green), BCU (white), Top Brent Gp (light blue), Top Dunlin Gp (dark blue stippled)

Geochemistry and basin modelling studies were performed to de-risk the prospects. The Firebird structure is a low relief three way dip closure formed against the hangingwall of a southeast-northwest trending fault system that bounds the Utsira High to the southwest. There is a high risk of trap integrity due to the limited throw of the main bounding fault and the reliance upon sealing across relay ramps where little or no displacement is seen. A fault seal study was performed for the Firebird prospect and results of this were applied in the updated volumetrics calculations, however faults seal is still the main risk for the Firebird prospect and is a critical risk that cannot be further reduced. For the Phoenix prospect the main risk is hydrocarbon charge.

Mapping of the Statfjord Fm is challenging also with the reprocessed seismic data, and the Top Statfjord surface is less well defined than the Top Brent surface. The basin modelling results also show that the Statfjord Fm is less likely to be a target in the Firebird prospect, volumetric and risk calculations including the Statfjord Fm has therefore only been performed for the Phoenix prospect.

The Tyson prospect targeting the Paloecene Ty sand has been further evaluated using the WIN14M02 reprocessed seismic. It is difficult to map the Ty Fm pinch-out line towards the east, and presense of sand in the Tyson remains a major risk. The Tyson prospect is viewed as a secondary target that might have been penetrated with the drilling of the Jurassic Phoenix prospect. No updates have been performed to volumes or risk.

Updated expected Recoverable Hydrocarbon Volumes (MM STB OE) and Geological Probability of Success (%) are given in table Table 4.1.

Table 4.1 PL 678 S/BS/C/SB Prospect recoverable volumes (mm stb oe) and Geological Probability of Success (GPOS)

	Reservoir	P90	P50	Mean	P10	GPOS (%)
Firebird	Brent Group	21.4	72.8	122.3	275.5	28.0
Phoenix Brent	Brent Group	3.3	14.2	28.6	66.2	9.0
Phoenix Statfjord	Statfjord Formation	1.0	12.0	30.6	81.4	13.4
Phoenix consolidated	Brent + Statfjord	1.9	15.2	33.5	82.5	18.9

5 Technical evaluations

N.A.

6 Conclusions

Wintershall Norge AS has recommended to fully surrender the PL 678S/BS/C/SB acreage in 2017. The main reasons are for the Firebird prospect that the trap effectiveness (fault sealing, trap integrity) represents a critical risk that cannot be further reduced. The structure is a low relief three way dip closure formed against the hangingwall of a southeast-northwest trending fault system that bounds the Utsira High to the southwest. There is a high risk of trap integrity due to the limited throw of the main bounding fault and the reliance upon sealing across relay ramps where little or no displacement is seen. Phoenix is a low relief four way dip closed structure. For the Phoenix prospect Wintershall's minimum economic field size requirements are not met. In addition, the charge risk is considered too high. The recommendation to surrender the license has been accepted by the majority vote of the license partners with the necessary decision voting criteria having been met.