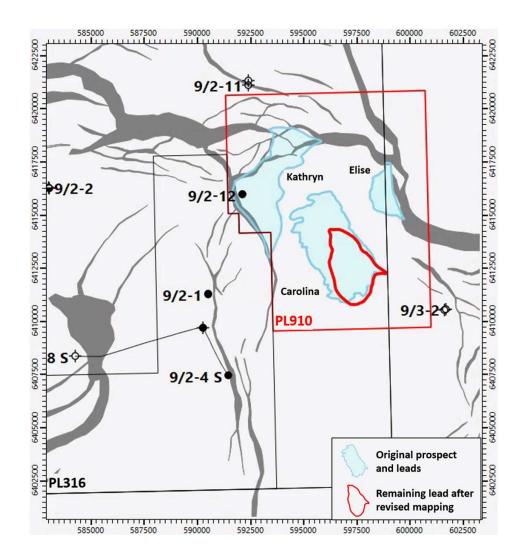
# **PL910 Status Report**



**Repsol Norge AS** 



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## 1 History of the production license

PL910 was awarded on March 2<sup>nd</sup>, 2018 as part of the APA 2017 license round to Repsol Norge AS (61.111%) as operator, and LOTOS Exploration and Production Norge AS (22.222%) and OKEA ASA (16.667%) as partners.

#### Initial work obligations and work periods

Within 1 year or before March 2<sup>nd</sup>, 2019

- Conduct geological and geophysical studies
- Drill or drop decision

Within 3 years or before March 2<sup>nd</sup>, 2021

- Drill exploration well
- Concretize (BoK) or drop decision

Within 5 years or before March 2<sup>nd</sup>, 2023

- Conduct conceptual studies
- Continuation (BoV) or drop decision

Within 6 years or before March 2<sup>nd</sup>, 2024

- Prepare development plan (PDO)
- Submit PDO or drop decision

#### Overview of meetings held

- Initial meeting: March 22<sup>nd</sup>, 2018
- Work meeting: May 30th, 2018
- EC/MC meeting: June 6<sup>th</sup>, 2018
- EC/MC meeting: October 25th, 2018
- Work meeting: November 5th, 2018
- Work meeting: December 4<sup>th</sup>, 2018
- Work meeting: February 20th, 2019
- EC/MC meeting: June 13<sup>th</sup>, 2019
- EC/MC meeting: October 31st, 2019

#### Grounds for surrender

The license work program was completed by conducting relevant geological and geophysical studies and drilling the 9/2-12 exploration well. Following the evaluation of the well results and completion of the work program, the partnership has concluded that no discovery has been found that can support a positive concretization decision. Based on this, the partnership decided unanimously to surrender the production license.

Type NPDID

3585

3391

4260

3023

3038

2896

3897

3D 4294

3D 4294 4036

2D

2D

2D

2D3521

2D

2D

2D

2D 2583

2D

2D 3056

2D

### 2 Database overviews

#### 2.1 Seismic data

The seismic database consists of publicly available 2D datasets, multiclient 2D datasets and publicly available 3D datasets within and near the license area. Initially the seismic interpretation of the licence area was carried out on MC3D-EGB2005 3D survey. Detailed structural interpretation over the prospects was carried out on PSDM reprocessed dataset, MC3D-EGBR13. The interpretation of the available 2D surveys was performed in order to better define regional trends, main tectonic phases as well as reservoir and source rock mapping and distribution on a wider area. All the seismic datasets used in the evaluation of the license are shown in Figure 2.1 and listed in Table 2.1.

> Survey MC3D-EGB2005

EBSOO

GFR-93

NSR04

SG8726

SH8707

ST8302

ST8606

ST8712

UG97 GC

GNSR-91 GC

MN9206-0C

Table 2.1 Seismic database

MC3D-EGB2005R12-BE-Geotrace

Year

2005

2000

1993

1991

1992

2004

1987

1987

1983

1986

1987

1997

2005/2012 reprocessing

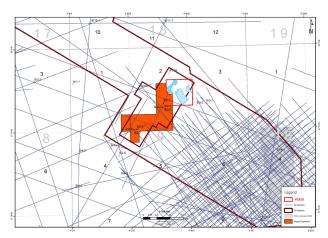


Figure 2.1 Coverage the seismic data used in the licence

#### 2.2 Well data

The well database consists of public and non-public wellbores used in the evaluation of the license. Table 2.2 lists all the wellbores used in the license.

Well name	Year	<b>Composite</b> logs	Checkshots	Core	Geochemistry	CPI	Pressure Data	NPDID		
9/2-1	1987	x	х	х	x	х	x	1038		
9/2-2	1987	x	x	x	x		x	1135		
9/2-3	1989	x	х	x	x	х	x	1294		
9/2-5	1995	x	x	x		x	x	2599		
9/2-6S	1996	x		х	x		x	2867		
9/2-7S	1997	X		х	x		x	3087		
9/2-11	2010	x				х		6341		
9/3-1	1986	x	х	х		x	x	921		
9/3-2	2005	x			x	x		5173		
9/4-1	1968	x			x	х		150		
9/4-3	1968	x	х		x			152		
9/4-4	1977	х	x		x			305		
10/4-1	2015	x				х	x	7724		
10/5-1	1976	x	x		x	x		306		
10/7-1	1002	x	х	х	x		x	1972		
10/8-1	1970	x	x		x	х		175		
17/12-1R	1972	x	х		x			514		
17/12-2	1973	x	x	х	x			340		
18/10-1	1980	x	х	x	x		x	342		
18/11-1	1974	x	x	x	x			343		

Table 2.2 Well database

# 3 Results of geological and geophysical studies

The special studies carried out in the licence area are listed in Table 3.1. The studies which were carried out after the licence was awarded are discussed below.

Study name	Year	Company
3D Gravity Modelling of Salt Structures in North Sea Block 9/2	1996	Statoil
Core description and sequence stratigraphy of the Sandnes Fm, Yme field	1998	Statoil
Biostratigraphic Conelation:Yme Field Area	1998	GeoStrata
Geochemical oil-correlation study: Bream, Brisling and Yme Fields	1999	Statoil
Depth and Timing of Neogene Erosion	2003	Globex Norway AS
Basin modelling Egersund Basin	2004	Aceca
Egersund Basin: Rock physics and seismic amplitude modelling	2004	R.P.A
PL316, Egersund Basin fault seal study	2004	Badleys
Regional Play Fairway Evaluation on the Norwegian North Sea	2005	PGL
A stratigraphic reconstruction of Bulk volatile geochemistry from fluid inclusion	2006	F.I.T
Multicomponent kinetics of a source rock from the Tau Fm	2006	Sintef
Pore pressure and vertical migration in the Yme area	2006	Sintef
Yme area petroleum system	2006	Sintef
Egersund basin: Basin modelling Study	2007	PGL
Bulk Kinetics of two samples from well 9/3-2	2007	APT
Technical note on the Jurassic reservoir in the Yme Field	2010	Ichron
Petroleum systems study and structural reconstruction	2019	Repsol
Fluid inclusion study, well 9/2-12	2020	Repsol
Geochemistry of the well 9/2-12	2020	Repsol

Table 3.1 List of the studies carried out in the licence

#### Petroleum systems study

New basin modelling study and structural reconstruction was carried out in order to better assess the main risk factors in the Egersund basin area, which were migration, amount of generated hydrocarbons and timing of the structures in relation to migration. The results from the analysis of the three oil samples from Yme field, heat-flow model which took into account crustal thinning, and a new seismic interpretation, were implemented to this study. As a sensitivity, a model where the heat-flow was defined with constant temperature gradient was also tested.

The model with constant temperature gradient suggested that the onset of oil generation took place ~72 Ma ago, whilst the more sophisticated model, which took into account the crustal thinning, suggested that onset of oil generation could have taken place already ~113 Ma.

Proven hydrocarbon volumes in the Yme Field were used for calibration of the parameters in this study.

#### Geochemistry study of well 9/2-12

The gas analysis showed that methane in the Early Cretaceous, and in the Tau formation was mainly of bacterial origin, respectively ~98 % and ~92 % of total gas. C2+ components are of thermogenic origin. Sandnes and Bryne gases are mixed gases (bacterial + thermogenic) where the thermogenic component is higher. Ethane and propane maturity for Sandnes and Bryne thermogenic component present in the total hydrocarbon gas range between Rc~1,0-1,2%, indicating that this Rc% better reflects the minimum thermal maturity of the source that has generated the thermogenic component of the gas present in Sandnes and Bryne, and for this reason, it can be inferred that gases present in Sandnes and Bryne formations are migrated gases. The results indicate in-situ origin for the gases in the Early Cretaceous, and Tau Formation.

#### Fluid inclusion stratigraphy study of well 9/2-12

A fluid inclusion stratigraphy (FIS) analysis was performed on a total of 228 cuttings samples in 9/2-12 from 1250-3155 m, with additional support from 6 selected samples for fluid inclusion petrography (FIP) and fluid inclusion microthermometry (FIM). No proximity to pay and mostly sub-anomalous hydrocarbon responses were recorded in the upper section at 1250-2985 m. The deeper section at 2988-3155 m recorded higher concentrations of methane and liquid-range species, suggesting that some natural migrated hydrocarbons are present and contributed from local mature kerogen. Rare petroleum inclusions are identified at 3012 m and 3036-3131 m, indicating petroleum migration at some time. Although proximity to pay indicators are not recorded, presence of uppermoderate gravity light oil inclusions may suggest that some hydrocarbons have been locally or proximally generated. Fluorescence color of dominant oil inclusions recorded in 9/2-12 seems to be consistent with the 38 gravity oil tested in the Yme Field to the west.

#### Summary

Fluid inclusion stratigraphy analysis (FIS) together with fluid inclusion petrography (FIP) and fluid inclusion microthermometry (FIM) reported the existence of hydrocarbon-bearing fluid inclusions, thus proving that hydrocarbons migrated through the reservoir sandstones of Sandnes and Bryne Formations at the 9/2-12 (Kathryn) well location. Microthermometry data from primary, dust-rim-hosted aqueous fluid inclusions, i.e., located at the detrital quartz grains/cement boundary, suggest the onset of quartz cementation occurred at minimum burial temperatures of ~90°C during the Early Cretaceous (~120 Ma). Presence of secondary (?) hydrocarbon-bearing fluid inclusions would be related to the onset of oil generation and migration through the reservoir during the latest Early Cretaceous (~113 Ma), when minimum reservoir temperatures could be estimated  $\sim$ T = 95-100°C as per basin modeling reconstruction – no microthermometry data on HC-bearing FIs was acquired.

### 4 Prospect update report

#### Prospect and leads

Originally one prospect, "Kathryn" and two, leads "Carolina" and "Elise" were identified in the licence area (Figure 4.1).

The Yme Gamma structure was used as an analogue for the trap in the Kathryn prospect. Common for the prospect and the leads was the Sandnes formation reservoir, the Tau formation source rock and the Egersund formation cap rock. The trap of the Kathryn prospect was defined by a 3-way dip-closure to the south-eastward and hanging wall fault seal to the north and west. On present day maps the Kathryn prospect is in the migration shadow.

Carolina lead was not considered a viable exploration target after the revised mapping, which reduced the closure area from the original 11.7 km<sup>2</sup> to 5.5 km<sup>2</sup> (Figure 4.1). The structure has only about 18 m relief, which would include only the two uppermost poor quality reservoir zones of the Sandnes formation.

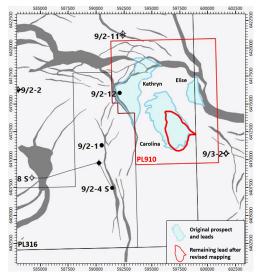


Figure 4.1 Original prospects and remaining lead in the licence area

Local structural reconstruction in the area from Kathryn prospect to the kitchen area showed that present day structural configuration, where the prospect is in migration shadow, was established sometime during the deposition of the Tor formation ~72 to ~66 Ma ago (Figure 4.2). This reconstruction also showed that the Elise lead have been in migration shadow through whole its geologic history.

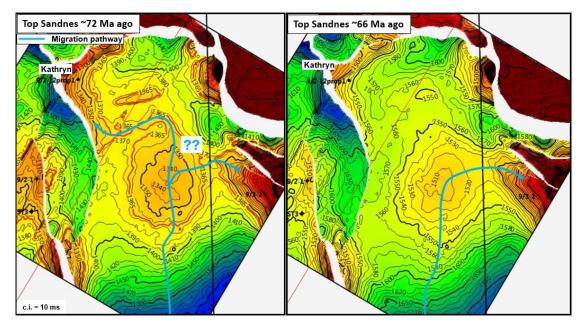


Figure 4.2 Change in migration pathway to Kathryn prospect ~72 to ~66 Ma ago

According to the 2019 petroleum systems study, which took into account crustal thinning, the onset of oil generation started ~113 Ma ago. This would leave over 40 Ma time window for expulsion to Sandnes carrier bed and secondary migration.

#### Well results

The well 9/2-12, which was drilled in the Kathryn structure did not discover hydrocarbons. The lithology in the well was as expected, very similar to the nearest reference well 9/2-1 in the Yme field. The Sandnes reservoir had slightly better reservoir parameters (N/G=0.66,  $\emptyset$ =0.17) than prognosed (N/G=0.53,  $\emptyset$ =13). Depth prognosis of the formation tops was within estimated uncertainty range apart from the Bryne formation, which appeared 3 m outside the range. Flekkefjord and Sauda formations are based on the formation tops with no interpretable seismic response and were not part of the prognosis (Figure 4.3). The geochemical analysis in the 9/2-12 well proved that no oil have migrated to the Kathryn structure.

Possible reasons for failure:

- 1. There are no faults, which juxtapose the source and carrier bed, hence the primary migration had to take place stratigraphically downward through the laterally homogeneous Egersund formation. Due to this mechanism, there may have appeared significant lag between primary and secondary migration. This factor could not be studied with the available data.
- 2. The northern shallower part of the Egersund basin did not generate enough oil to increase the pressure in the Tau formation, which is needed to start the primary migration through the Egersund formation.
- 3. Primary migration was triggered by fracturing during the late Cretaceous tectonic activity or by Miocene uplift, which would have increased the pore pressure in the oil filled source rock. In this case, the migration pathway would already have turned to the north-east, leaving the Kathryn structure in the migration shadow.
- 4. The fetch area was so small that no oil reached the structures.

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UPPER CRETACEOUS

+23

LOWER CRETACEOUS CROMER KNOLL

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Figure 4.3 Well 9/2-12 geologic prognosis vs. actual

Difference (+=actual deeper)

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Seismic markers in red

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-29



# 5 Technical evaluation

Since the exploration well 9/2-12 did not discover any hydrocarbons in the Kathryn prospect, no technical evaluation has been carried out.

## 6 Conclusion

The well 9/2-12 drilled in the Kathryn prospect did not discover any hydrocarbons. The revised mapping and structural reconstruction showed that the only other potential exploration targets, Carolina and Elise leads, could not be matured into prospects.

Since no other drillable prospects have been identified, the partnership has unanimously decided to surrender the production licence.