



## PL959/959B Licence Status Report

## Summary

PL959/959B is located on the border between the deep Cretaceous Møre and Vøring basins, including the Cenozoic Modgunn Arch and located to the west of the Cenozoic Helland Hansen Arch. Three exploration wells and two shallow boreholes are located within the 3D area: Edvarda (6403/6-1), Kanel (6505/10-1), Gemini (6504/5-1 S), 6403/1-U-1 and 6406/5-GB1.

The 3D seismic dataset AMN17 has been interpreted for the PL959/959B license. Location of the license and AMN17 is shown in Figure 1, a.

The AMN17 is a 15520 km<sup>2</sup> PSTM Multiclient 3D seismic survey, which was acquired from 5<sup>th</sup> of July to 21<sup>st</sup> of September 2017 by TGS. Wells within the survey are shown in Figure 1.

The probable reservoir intervals have been mapped out where possible, and the conclusions presented are based on the consideration of sediment fairway theories in the area together with well and seismic (amplitude) observations for the mapped closures.

The prospect that has been worked the most in the license is the Butzen prospect in the Naust Fm. (Figure 1, a and b) the location of the other prospects in the license (Grågåsen, Barden and Gorsuden, Tare, Tang and Springar fms.) are shown in Figure 1, b).

The AMN17 seismic data set is covering a large area, and the existing wells are placed far apart around the Modgunn Arch. The result is that the work done for PL959/959B will inevitably have lower confidence than in more mature exploration areas and conclusions are based on a combination of less hard facts and more model thinking.

With the work performed in the PL959/959B license area, no hydrocarbon trap of significant size with high chance for working reservoir has been identified. This leads to the conclusion that the area has a challenging prospectivity.

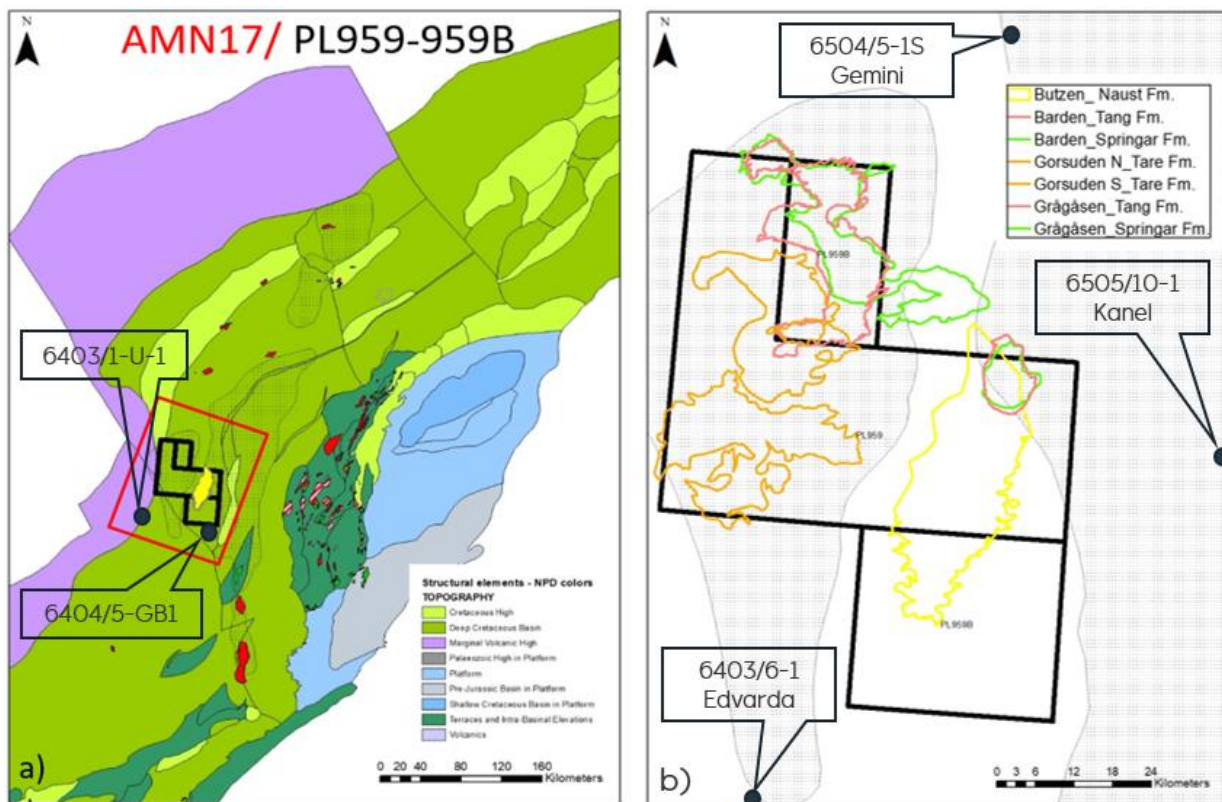


Figure 1: a) The location of PL959/ 959B and AMN17 (TGS) 3D seismic data set. Position of shallow bore holes 6403/1-U-1 and 6404/5-GB1. b) PL959/959B prospects (Naust, Tare and Tang fms.) and leads (Springar Fm.). Position of exploration wells Gemini (6504/5-1 S), Edvarda (6403/6-1) and Kanel (6505/10-1).

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## 1 License Overview

### Partnership:

Equinor Energy AS (op) 50%, M Vest Energy AS 10%, Spirit Energy Norge AS 20%, Petoro AS 20%

Valid: 22.06.2018-22.06.2025

G&G and 3D seismic purchase, CSEM decision or DoD (22/6-2021)

### Meetings in license:

2018.08.14: ECMC No. 1

2018.11.29: ECMC No. 2:

- AMN17 data quality and AVO work plan

2019.03.21: EC WM:

- Prospectivity Butzen
- AVO on Paleocene (Grågåsen) and Pleistocene (Butzen)

2019.06.13: ECWM

- CSEM feasibility study

2019.11.29: ECMC No. 3

- Butzen update

2020.05.12: EC WM

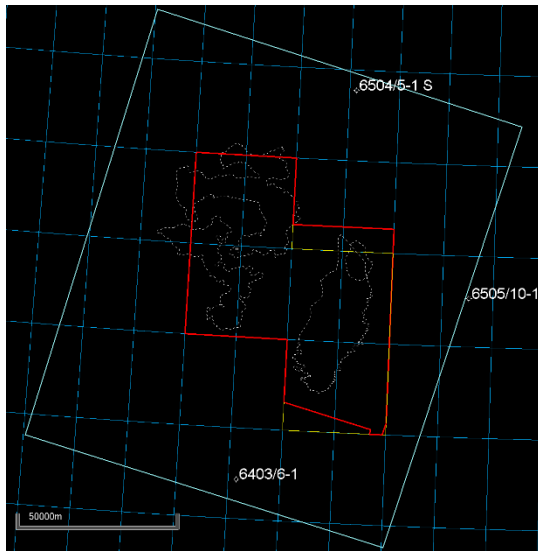
- Apex technology

2020.13.11

- Prospectivity report and Petrel project available for license partners

2020.12.02: ECMC No. 4: Status of licence prospectivity

## 2 Database



AMN17 (3D) all stacks: 3585 km<sup>2</sup> (red outline)

Main wells:

6504/5-1 S

6505/10-1

6403/6-1

6405/2 GB1

6414/5 GB1

Figure 2: 3D seismic common database for PL959/959B AMN17.

## 3 Geological and Geophysical studies performed

The PL959/959B area has been evaluated geologically and geophysically with the AMN17 3D seismic dataset and generated sub cubes from regular AVO workflow at various depths. So-called lithology (relative S-impedance and Vp/Vs) and fluid cubes (EEI) have been used to screen for possible HC-filled reservoirs within the entire stratigraphic column of the license area.

CSEM (Controlled Source Electromagnetic Technology) and Dispersion technology have been evaluated especially for the shallow prospect Butzen to possibly provide more data on saturation and permeability, but the conclusion is that de-risking potential of these techniques is not adequate compared to cost and intrinsic uncertainty in interpreting the results. Possible reservoir properties and the stability of gas hydrates as part of the trapping mechanism for the Butzen prospect has been investigated both inhouse Equinor and together with NGI.

## 4 Prospect Update

### Butzen

The Butzen prospect is a large, flat, amplitude driven opportunity in the Pleistocene Naust Fm. Due to the clear shut-off of strong amplitudes along mapped bottom simulating reflector (BSR- representing the base of gas hydrates) it was identified as trapped gas.

The key risk for the Butzen prospect is reservoir presence and quality. Presence of a traditional sandstone-reservoir containing a large producible volume gas has a *very low probability*. Geophysically it is difficult to separate between gas in reservoir or gas in non-reservoir. In addition, discrimination between high or low saturation gas is difficult and is a remaining uncertainty. Limitations in generation of microbial gas in the time frame of retaining with current mapped trap area expected as the current mapped BSR as part of the seal for Butzen only became stable <20 000 years ago.

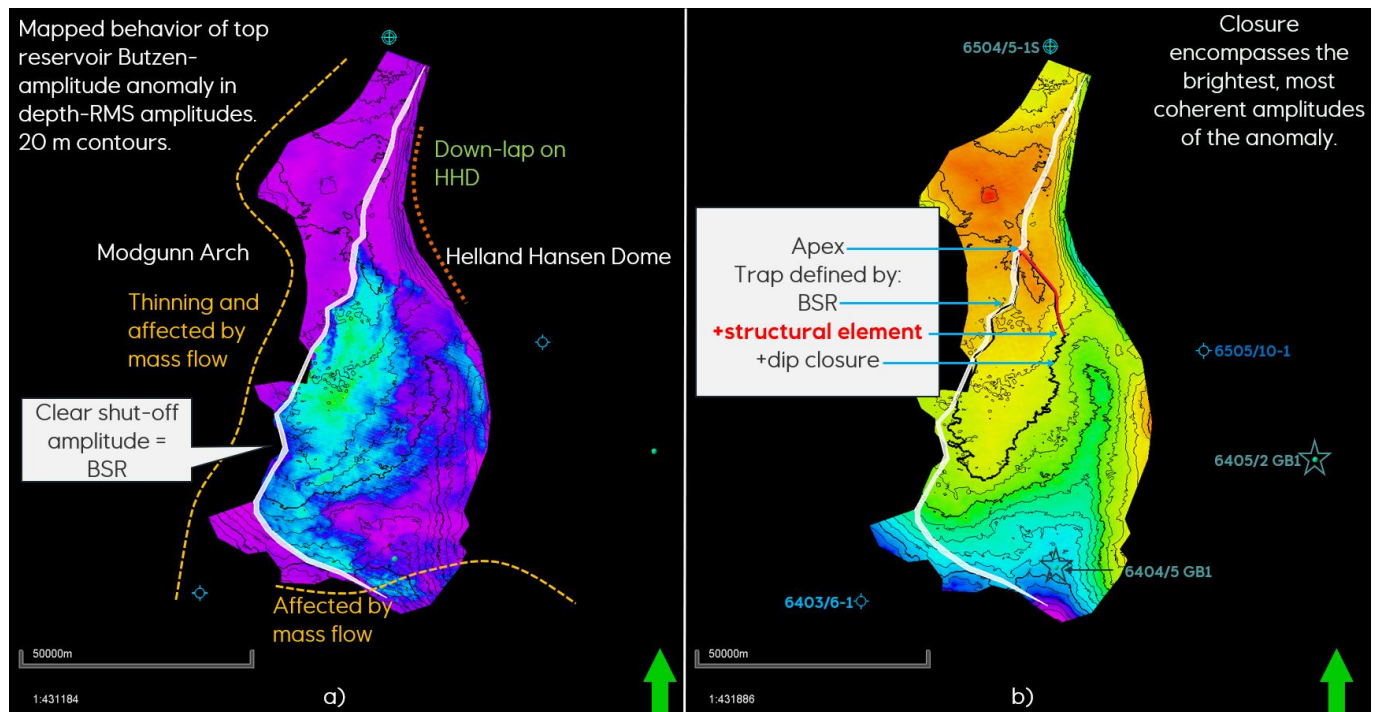


Figure 3: Butzen a) Top reservoir mapping and RMS amplitudes. b) Trap definition on depth map. AMN17 TGS.

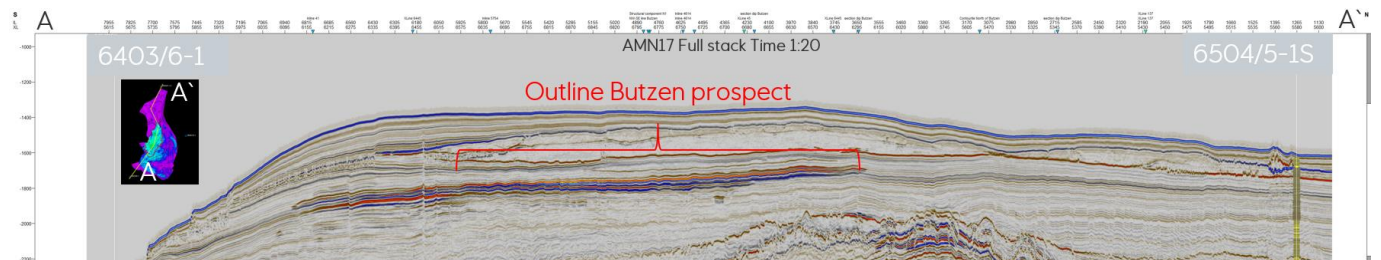


Figure 4: Butzen seismic section (AMN17 Time TGS).

### Grågåsen and Barden

The Paleocene prospects Grågåsen and Barden were part of the main prospectivity in the 24R application on Modgunn Arch. All prospectivity was at that time carried out on 2D seismic. These Paleocene closures are located on the Modgunn Arch, which has been identified as a likely migration focus point for both oil and gas, expelled from Cretaceous source rocks. Prospectivity within the awarded PL959/959B has been redefined on 3D seismic AMN17 and two closures are evaluated on Paleocene level, the Grågåsen East and the Barden prospects. Key risk for the prospects is reservoir presence.

Four closures are mapped out at Tang Fm. and Springar Fm. level. The key risk for these prospects is reservoir presence/quality and geophysical response. The sediment fairway from East Greenland is believed to exist in both Cretaceous and Paleocene times. However, in Paleocene times, the Kolga high has acted as a barrier, resulting in higher risk for sediments to enter the Modgunn Arch and higher risk to the quality of the sand that may have entered the prospectivity area. The three nearby wells to Modgunn Arch support the depositional models by showing no signs of sand in Paleocene and only thin and few sand stringers in Cretaceous, below the Springar level. The data quality of AMN17 is good at the location of Grågåsen East and Barden level and the confidence in both seismic interpretation and quantitative



geophysical evaluation is good. At Cretaceous level the data quality is less good, and sills and dikes are disturbing the imaging, resulting in less confidence at Springar level. Furthermore, temperatures are reaching the reservoir cut-off values towards the Lysing Fm. level. The performed quantitative geophysical evaluation at both Paleocene and Cretaceous levels show these intervals to be dim and eventless. With the data available at this stage, it has not been possible to mature any drillable prospects in Paleocene and Cretaceous.

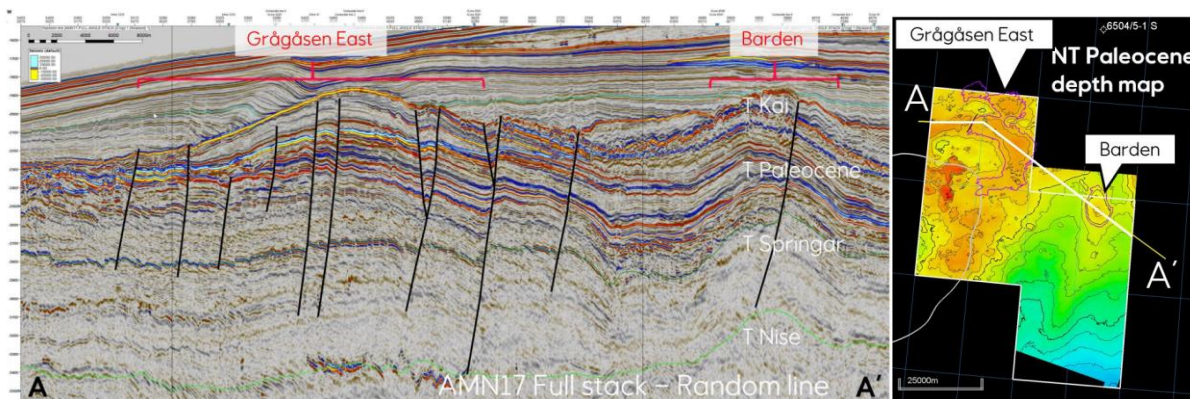


Figure 5: Grågåsen and Barden seismic section (AMN17 Time TGS) and depth map.

### Gorsuden

The Gorsuden N prospect was initially put forward by M Vest. The prospect is a clearly visible fan system filling in Palaeocene topography on the Modgunn Arch. The age of the sediments is expected to be Thanetian/ Ypresian. Direction of sediment transport is from West to East/ South East. The fan has several lobes where thickness ranges from ~60 m in the Western part to an Eastern pinch out of the system. A strong soft top reflector and a strong hard base reflector is easily mapped, and the interval between has strong reflectivity where the event is thicker than one seismic cycle. The fan shows an amplitude anomaly, as seen in Figure 6, RMS amplitude from AMN17. There are two depositional models which can explain the observations:

- a) Sand coming from Greenland into the Basin via depression related to the Jan Mayen lineament. Enabling crossing any marginal high. (In Early Palaeocene Greenland was only approximately 100 km away from Gorsuden area.)
- b) Erosional products from an elevated volcanic margin to the West.

Geophysical investigation of the fan lobes 1 and 2 of the fan system shows:

- Amplitudes are not depth- conformant but show perfect alignment with thickness contours
- Amplitudes dim with offset- AVO class 4
- Sediment shows soft s-impedance (a hard S-impedance is expected for typical Quartz sst.)

In addition to high risk on reservoir the prospect has high risk on trap seal as there are multiple hydrothermal vents and fractures cutting the prospect. Gorsuden S has not been evaluated.

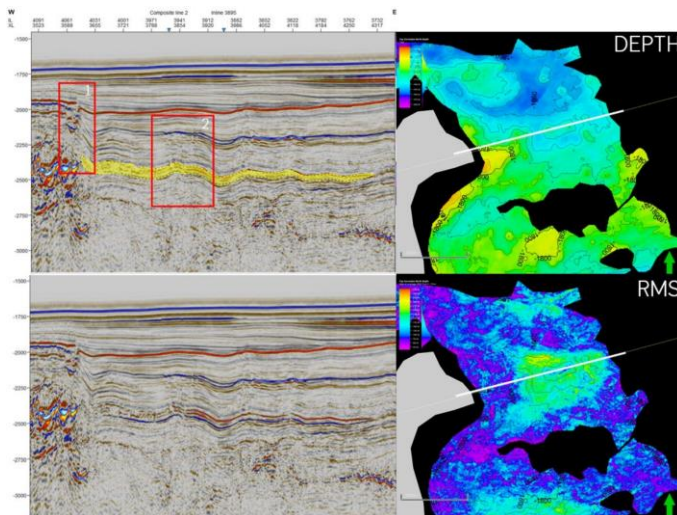


Figure 6: Gorsuden North seismic section (AMN17 Time TGS) and depth map with RMS amplitudes. Highlighted 1 and 2 are areas with especially high risk for trap seal due to shallow structural events.

Table 1: Summary prospect volume and risk.

Prospect	In-place res. (MSm3 OE) 100 % Total structure			Recoverable res.(MSm3 OE) 100 % Total structure			Pg   DFI
	P100	Mean	P0	P100	Mean	P0	
Butzen	4	27	103	2	<b>16</b>	62	0,03
Grågåsen	5	115	789	3	<b>46</b>	243	0,06
Barden	4	32	149	3	<b>13</b>	49	0,07
Gorsuden	4	58	398	2	<b>29</b>	170	0,01

## 6 Summary and Conclusion

The evaluation of the PL959/959B has not led to the identification of any drillable prospect. PL959/959B license is located far away from closest existing infrastructure and any drillable target needs substantial volume potential for an economic tie-back or a stand-alone development. Deep water tie-back candidates with long stretches of gas transport pipe are expected to have issues with formation of gas hydrates, so larger volume accumulations are desirable for stronger prospect economy where mitigation actions need to be taken.

The Jurassic and deeper Cretaceous interval are not considered prospective due to lack of reservoir properties from exposure to high temperatures. These intervals have no clear AVO anomalies. The closest wells indicate general deep-marine distal settings with some sandstone stringers.

The upper Cretaceous and Paleocene intervals are characterised by tuffaceous clay in the wells. The limited presence of sandstone in the wells results in challenging prospectivity at these levels and is supported by the AVO evaluation (lithology- and fluid cubes). The Upper Cretaceous section is highly faulted (Figure 5) and segmentation is therefore a risk to development of this level.

Some limitation to the sediment input from the West is expected from Early Paleocene times as the marginal high was elevated pre seafloor spreading. This may have affected the Grågåsen, Barden and Gorsuden prospects.

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The very high-risk prospect Butzen (Naust Fm.) does not show economic robustness. The expected large number of gas producers needed to achieve an economic production profile- the low pressure, and subsequent energy consumption to produce the gas, is expected to leave an unacceptably large CO<sub>2</sub> footprint (>14 kg/ boe) for a development.

The lack of any mapped economically viable prospect with acceptable risk leads to the conclusion that the area has challenging prospectivity. The license PL959/959B was dropped at the license milestone DoD 22<sup>nd</sup> of June 2021.

**Attachments:**

Table 5 for Butzen, Barden, Grågåsen and Gorsuden prospects.