

# PL645 Relinquishment Report



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## 1 Key Licence History

### Licence details

PL645 is located in block 6507/10 on the Halten Terrace approximately 14 km south of the Heidrun Field (Fig. 1.1). The licence was awarded to Faroe Petroleum Norge AS, Centrica Resources (Norge) AS and Skagen44 AS in 2012 as part of the APA 2011 round.

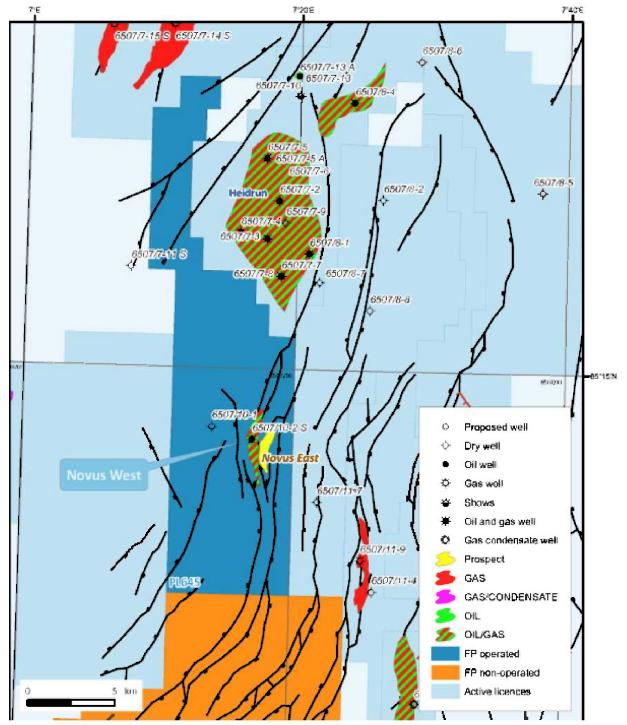


Fig. 1.1 Location map.

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In 2013 Concedo ASA acquired 5% equity in the licence from Skagen 44, Spike Exploration Holding AS acquired 15% equity from Faroe Petroleum Norge AS and Concedo ASA aquired 5% equity from Faroe Petroleum Norge AS, leaving license equity at the termination of the licence as follows:

Faroe Petroleum Norge AS (Operator) - 30%

Centrica Resources (Norge) AS - 40%

Spike Exploration Holding AS - 15%

Concedo ASA - 10%

Skagen 44 AS - 5%

### Work program

The licence work performed included seismic reprocessing, geological and geophysical studies before making a drill decision. This work commitment was fulfilled with the drilling of the discovery well 6507/10-2S drilled in 2013. The well results have been evaluated together with the impact of the remaining prospects in the licence towards the BoK licence decision.

The work programme for the licence has been fulfilled.

## Relinquishment

Following completion of all technical work, the partnership agreed to fully relinquish the licence and the notice of relinquishment letter was sent to the Ministry of Petroleum and Energy 3 August 2015.

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## 2 Database

#### Seismic database

The initial seismic database in PL645 consisted of the ST9905, CE0801, MGW98-R11, MGW98, CN-86, ST9102 and BPN0002. During the licence work programme, the merged reprocessed survey FP13M1 (MGW98, CN-86, ST9102 and BPN0002) and FP11M1R14 (reprocessing of MGW98) were added to the seismic database. The primary seismic dataset used in the interpretation of this area is the FP13001M1.

FP13001M1 is a merge of the ST0614MR10, MGW98 and the ST97M1. The dataset is amplitude, phase and time matched and post-stack reprocessed, across the licence area with the Heidrun Field to the north. The dataset has also been further reprocessed by SIP (Seismic Image Processing) sub creating derived products like angle stacks and seismic inversion for fluid and lithology prediction. The outline of the FP13001M1 dataset in relation to the discovery can be seen in Fig. 2.1.

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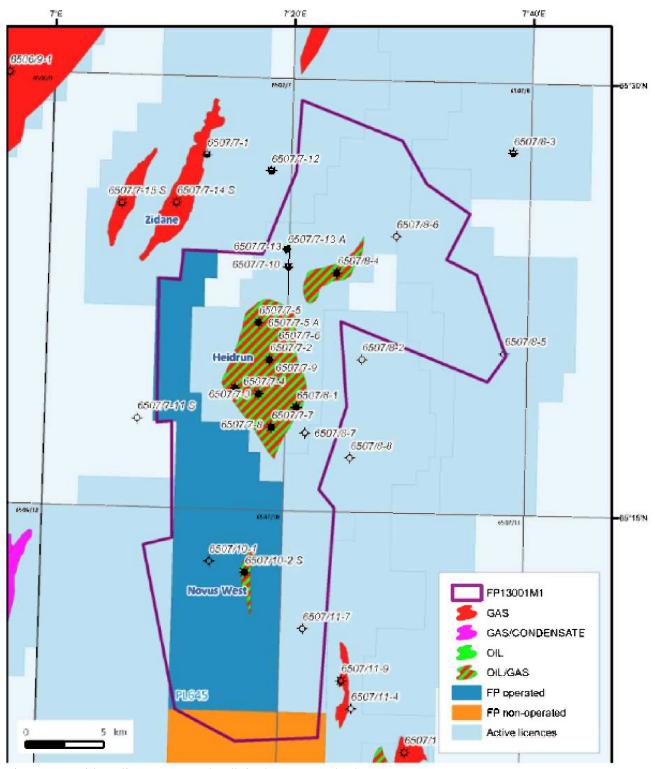


Fig. 2.1 Map with outline FP13M1 and wells in the common database.

### Well database

The well database can be seen in Fig. 2.1 and Table 2.1 and consist of all released exploration wells in the area and released production wells on Heidrun, Smørbukk and Smørbukk Sør.

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Table 2.1 Well database

Well	Durmoss	Veer	Dogult	TD	TD Formation	Primary	Secondary	Comment	
weii	Purpose	Year	Result	(m RKB)	TD Formation	target	target	Comment	
6406/3-3	Appraisal	1986	Oil shows	4416	Åre Fm.	Fangst Gp.			
6406/3-5	Wildcat	1988	Oil shows	4281	Tilje Fm.	Fangst Gp.			
6406/3-8	Wildcat	2010	Oil	4138	Tilje Fm.	Fangst Gp.		Maria Discovery	
6407/1-3	Wildcat	1984	Oil/Gas	4467	Grey Beds	Fangst Gp.		Tyrihans Nord discovery	
6407/1-4	Appraisal	1996	Oil/Gas	3805	Not Fm.	Fangst Gp.	Nise Fm.	Tyrihans Nord Appraisal	
6407/1-5 S	Appraisal	2012	Oil/Gas	4164	Tilje Fm.	Fangst Gp.		Maria Appraisal	
6407/2-1	Wildcat	1982	Oil shows	3869	Red Beds	Fangst Gp.			
6407/2-2	Appraisal	1985	Gas/Cond	3351	Grey Beds	Fangst Gp.			
6407/2-4	Wildcat	2009	Dry	3000	Ile Fm.	Fangst Gp.			
6506/12-5	Appraisal	1986	Oil	4587	Åre Fm.	Fangst Gp.	Lysing Fm.		
6506/12-8	Appraisal	1988	Oil/Gas	4334	Tilje Fm.	Fangst Gp.			
6507/10-1	Wildcat	1982	Dry	3687	Åre Fm.	Fangst Gp.			
6507/11-1	Wildcat	1981	Gas/Cond	3138	Grey Beds	Fangst Gp.			
6507/11-10	Wildcat	2010	Dry	2319	Tilje Fm.	Båt Gp.	Fangst Gp.		
6507/11-2	Wildcat	1982	Dry	2905	Grey Beds	Fangst Gp.			
6507/11-3	Appraisal	1985	Oil/Gas	3250	Grey Beds	Fangst Gp.	Båt Gp.		
6507/11-4	Wildcat	1987	Dry	3043	Tilje Fm.	Fangst Gp.			
6507/11-5 S	Appraisal	1997	Oil/Gas	2599	Ror Fm.	Fangst Gp.		Reclasified to producer	
6507/11-6	Wildcat	2001	Gas/Cond	3439	Åre Fm.	Fangst Gp.	Lysing Fm.	Sigrid discovery	
6507/11-8	Wildcat	2007	Gas	2772	Åre Fm.	Fangst Gp.	Båt Gp.	Yttergryta discovery	
6507-11-9	Wildcat	2008	Gas	3058	Båt Gp.	Fangst Gp.		Natalia discovery	
6507/7-1	Wildcat	1984	Gas shows	4818	Tilje Fm.	Fangst Gp.	Båt Gp.		
6507/7-10	Wildcat	1993	Oil shows	3306	Grey Beds	Fangst Gp.	Båt Gp.		
6507/7-11 S	Wildcat	1997	Dry	3744	Åre Fm.	Fangst Gp.	Båt Gp.		
6507/7-12	Wildcat	1999	Oil shows	3974	Spekk Fm.	Fangst Gp.	Lysing Fm.		
6507/7-13	Wildcat	2001	Oil	2623	Åre Fm.	Båt Gp.		Horst on the side of Heidrun	
6507/7-13 A	Appraisal	2001	Oil	2519	Åre Fm.	Båt Gp.			
6507/7-14 S	Wildcat	2010	Gas	4477	Tilje Fm.	Fangst Gp.	Lange fm.	Zidane discovery	
6507/7-15 S	Wildcat	2012	Gas	4552	Tilje Fm.	Fangst Gp.	Lange fm.	Zidane West discovery	
6507/7-2	Wildcat	1985	Oil/Gas	3260	Åre Fm.	Båt Gp.		Heidrun discovery	
6507/7-3	Appraisal	1985	Oil/Gas	2850	Åre Fm.	Fangst Gp.		Heidrun appraisal	
6507/7-4	Appraisal	1986	Oil/Gas	2850	Tilje Fm.	Fangst Gp.		Heidrun appraisal	
6507/7-5	Appraisal	1986	Oil/Gas	2659	Tilje Fm.	Fangst Gp.	Båt Gp.	Heidrun appraisal	
6507/7-5 A	Appraisal	1986	Oil/Gas	2525	Tilje Fm.	Fangst Gp.	Båt Gp.	Heidrun appraisal	
6507/7-6	Appraisal	1986	Oil/Gas	2470	Åre Fm.	Fangst Gp.	Båt Gp.	Heidrun appraisal	
6507/7-8	Appraisal	1987	Oil/Gas	2855	Åre Fm.	Fangst Gp.	Båt Gp.	Heidrun appraisal	
6507/8-1	Appraisal	1986	Oil/Gas	2600	Åre Fm.	Fangst Gp.	Båt Gp.	Heidrun appraisal	
6507/8-2	Wildcat	1987	Dry	2690	Åre Fm.	Fangst Gp.			
6507/8-3	Wildcat	1988	Gas shows	2075	Åre Fm.	Fangst Gp.			
6507/8-4	Wildcat	1990	Oil/Gas	2559	Grey Beds	Båt Gp.		Heidrun Nord discovery	
6507/8-5	Wildcat	1991	Dry	2000	Tilje Fm.	Fangst Gp.			
6507/8-6	Wildcat	1993	Dry	2850	Red Beds	Fangst Gp.	Båt Gp.		
6507/8-7	Wildcat	2004	Dry	2975	Tilje Fm.	Fangst Gp.	Lysing Fm.		
6507/8-8	Wildcat	2011	Dry	2554	Åre Fm.	Båt Gp.			

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## 3 Review of Geological Framework

The licence is located on the Halten Terrace south of the Heidrun Field. Prospectivity has been identified using seismic anomalies and sits mainly in tilted fault blocks with reservoir in the Jurassic section, ranging from the Garn Formation through to the Åre Formation.

### Reprocessing

Geotrace performed a reprocessing of the BPN0002, ST9102, CN86 and MGW98. Figure Fig. 3.1 show that the FP13M1 gave a general uplift in the seimsic data, improved well ties and imaging compared to the 2011 reprocessing. In addition, a Bandwith Extension (BE) was performed to the reprocessed seismic wich gave crisper faults, better resolution of the Fangst Group and good seismic character was maintained over the faults, the results are shown in Fig. 3.2.

#### Well results

The well 6507/10-2 S was drilled as an exploration well targeting the Garn, Ile and Tilje formations and was spudded on 10 November 2013. The objective was to find commercial volumes of hydrocarbons similar in composition to the nearby Heidrun Field. The well was TD'ed at 2678 m MD, 50 m into the Åre Formation (work commitment) and permananetly plugged and abandoned as a small gas and oil discovery.

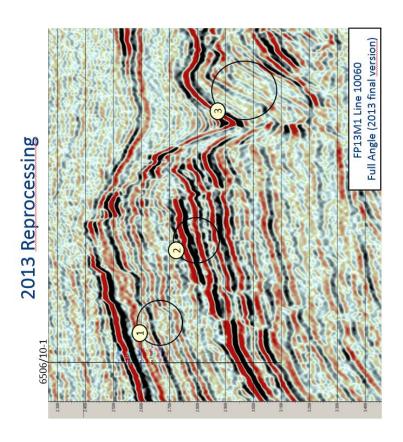
The well showed around 12 bar higher pressure than prognosed within the Garn and Ile formations, most likely due to compartmentalisation. Reservoir pressures acquired within the Tilje formation were lower than hydrostatic and interpreted to be depleted by Heidrun production.

Well 6507/10-2 S targeting the Novus West horst block encountered a 12.1 m net gas and a 10.5 m net oil column in the Garn Formation, which had a higher reservoir quality and thickness than expected. The Ile and Tilje formations were encountered in line with expectations, but were found to be water wet. MDT pressure points were taken in the Garn, Ile and Tilje formations, giving strong indications of fluid columns and contact. The Gas-Oil Contact (GOC) is located at 2605.4 m TVD SS, the Oil-Water Contact (OWC) is at 2618.0 m TVD SS. The bottom section (2 meters) of the Garn Formation is water bearing. Formation fluids (gas, oil, and water) were samples with MPSR and SPMC MDT bottles, with a high quality level, allowing to perform further PVT analysis.

The post-drill recoverable volumes are estimated to be P90: 0.8 million Sm<sup>3</sup> o.e. (5.1 MMboe), P50: 1.18 million Sm<sup>3</sup> o.e. (7.4 MMboe) and P10: 1.7 million o.e. Sm<sup>3</sup> (10.8 mmboe). Current volumes are classified sub-commercial.

Further details can be found in the '6507/10-2 S Novus Discovery Evaluation Report'.





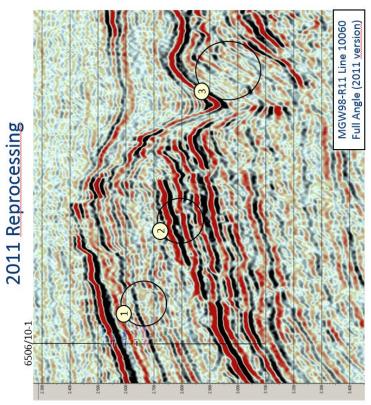


Fig. 3.1 Comparison between the 2011 and 2013 reprocessing 1. Slight improvement of imaging of the Båt interval

- 2. Better Åre continuity
- 3. Better imaging of steeply dipping reflectors



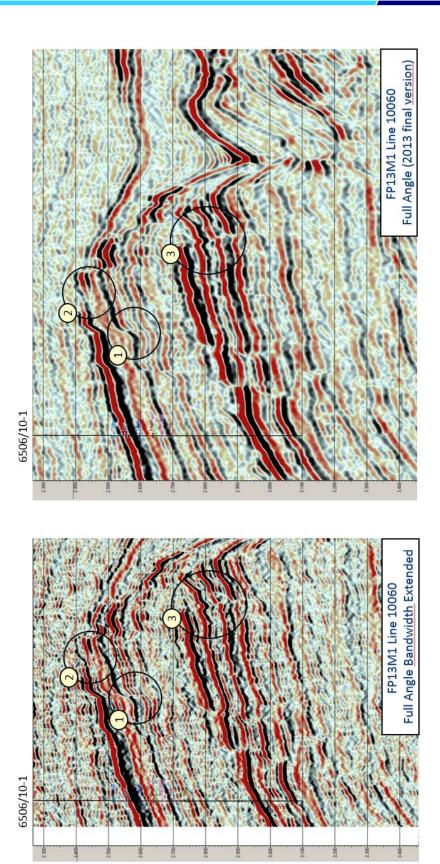


Fig. 3.2 Effect of bandwith extension (BE) in FP13M1

- 1. Crisper faults
- 2. Better resolution of the Fangst Group
- 3. Good seismic character maintained over the faults



#### **Fault Seal Study**

A fault seal study was initiated with RDR and the findings show that low throw displacement faults can be sealing. Well results show there is a pressure difference between Garn Formation in 6507/10-1 and 6507/10-2 S (Novus). There are no large throw faults between the two wells and hence it is believed the well proved the study to be right for this area.

### Biostratigraphic study

Ichron, on behalf of the partnership, carried out a biostratigraphic review of the Jurassic strata from Blocks 6506/12, 6507/7 and 6507/10. This provided a unified terminology and framework for further evaluation, biostratigraphic control and increased stratigraphic understanding of the PL645 licence area. The findings were minor changes to the NPD tops in some wells.

### Petroleum system

The gas cap and oil leg in 6507/10-2 S Novus is most likely originated by spill from the Smørbukk Sør Field (Jurassic), 6406/3-8 Maria and local charge from the primary drainage area of Novus (Fig. 3.3). Spill from Maria is not sufficient to explain the two-phase setting in Novus due to the low GOR in the hydrocarbons. The fact that there is an oil leg in Novus suggests that the available gas volumes are somewhat restricted compared to the oil volumes. This is also supported by relatively low gas contents in the accumulations that have spilled surplus charge to this migration route.

## Rock physics and AVO modelling

A number of direct hydrocarbon indicator methods have been used in the evaluation of the discovery and other prospects/leads in the area. The area is fortunate in being located adjacent to the Heidrun Field where methods can be developed and calibrated. When applied correctly, direct hydrocarbon indication methods can significantly impact the prospect risk, sometimes positively, where good indications of a hydrocarbon response is detected. Traditional amplitude maps, based on full offset data, can sometimes give risk reductions, particularly where the amplitudes conform to the structural closure. However post-stack full offset amplitudes can be problematic, and this requires that the data is analysed pre-stack. This data, combined with Rock Physics modelling, makes a more robust prospect definition and hence risk reduction.

A comprehensive Rock Physics study has been carried out as part of the licence work programme. This included a number of key wells in the Jurassic section, including those from Heidrun, Smørbukk, Smørbukk Sør and the Maria Discovery. The findings from the study, together with the well results show that it is difficult to differentiate between gas and oil.



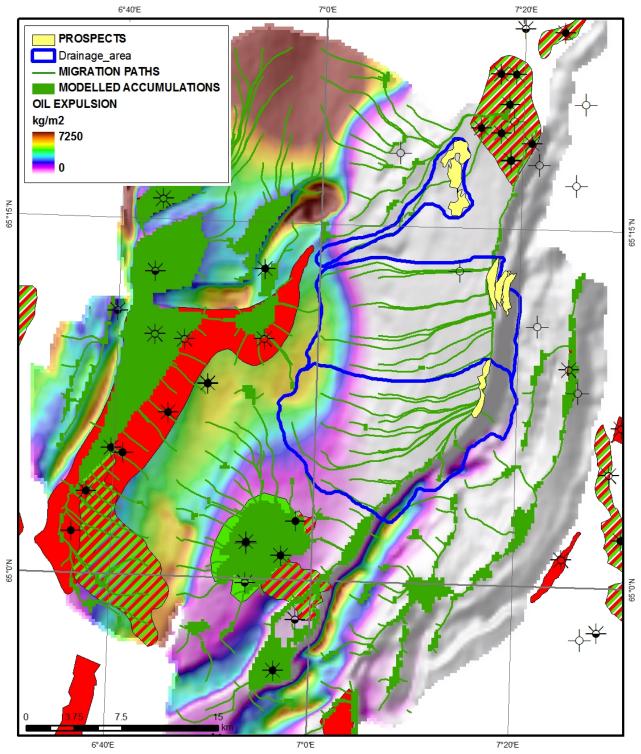


Fig. 3.3 Migration model (Torena)



## 4 Prospect Update

The main prospect in the licence was the Novus West Prospect wich was a small discovery. Considering the results of the Novus well, the remaining prospectivity in the licence has been evaluated and the main prospects are shown in Fig. 4.1. The Novus Discovery and the prospects in the licence are supported by a far offset anomaly also seen over the Heidrun Field Fig. 4.2. We see a high correlation between high amplitudes and thicknesses between 30-40 ms.

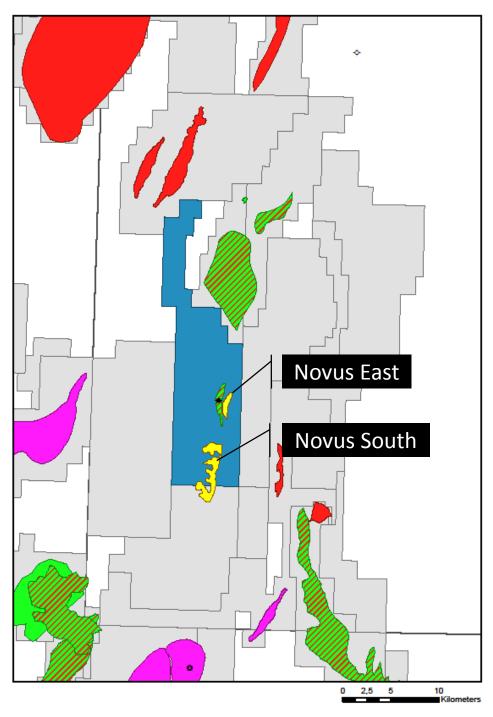


Fig. 4.1 Remaining prospectivity

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### **Novus South Prospect**

Trap

The trap on the Novus South Prospect is not well defined and requires a sealing fault not seen on seismic or a stratigraphic component. The trap has been defined based on far angle amplitude anomalies. These anomalies change between different vintages of seismic data and has increased the risk of trap presence (Fig. 4.2).

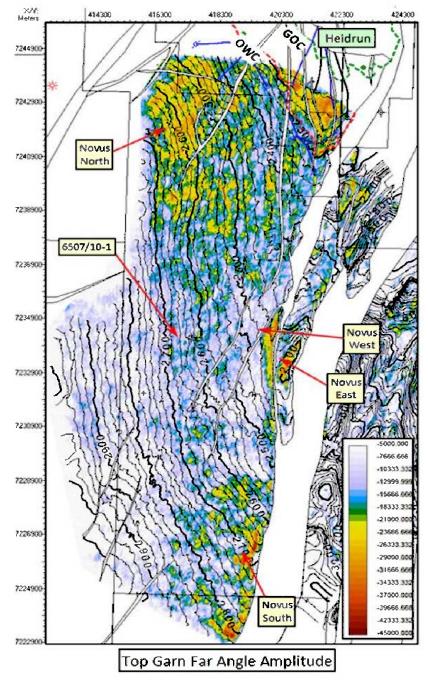


Fig. 4.2 Top Garn Amplitude Map

Amplitude anomalies can be seen over the Novus West discovery and over the remaining prospects in the licence.

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#### Reservoir

Reservoir for the Novus South Prospect is considered to be stacked Middle Jurassic Garn, Ile and Tilje formations. Reservoir has very good reservoir properties in the Novus West well and is expected to have similar characteristics in Novus South. Deposits are interpreted to be wave dominated clastic shoreline sandstones fed by major distributary systems, and is the classic Garn Formation model.

#### Charge

Novus South has access to a large catchment area of mature source rock. Several basin models has been developed and the trap is easily filled, so charge is considered a very low risk.

#### Source

The Spekk formation is a proven source in the area.

#### Seal

Updip seal towards Novus West has a high risk due to the presence of high permeability sandstones in the well that will also be present along the fault plane. The prospect requires the presence of a sealing, low displacement fault or a stratigraphic pinch out, to be able to trap hydrocarbons. Pressure results from the Novus well makes the presence of a sealing fault possible but now clear faults are seen on the seismic.

#### **Novus East Prospect**

#### Trap

The Novus East Prospect is a down thrown tilted fault block with a robust closure. Upside case for the prospect is as shown in Fig. 4.3 dependent on fault seal between the Garn/Ile reservoir in Novus East and the Tilje formation in Novus West. This has been taken into account in the volume calculation as well as included in the risking.

#### Reservoir

Reservoir is expected to be similar to the drilled Novus West structure and Novus south prospect and is not considered to have a very low risk.

#### Charge

Two possible models for charging the Novus East Prospect have been proposed. One is through direct charge from the Spekk formation in the Grinda Graben. The Spekk formation is juxtaposed with the flank of the prospect. The other migration route is across the eastern bounding fault into the Garn, Ile and Tilje reservoirs. Risk of the Novus East structure not beeing charged is considered very low.

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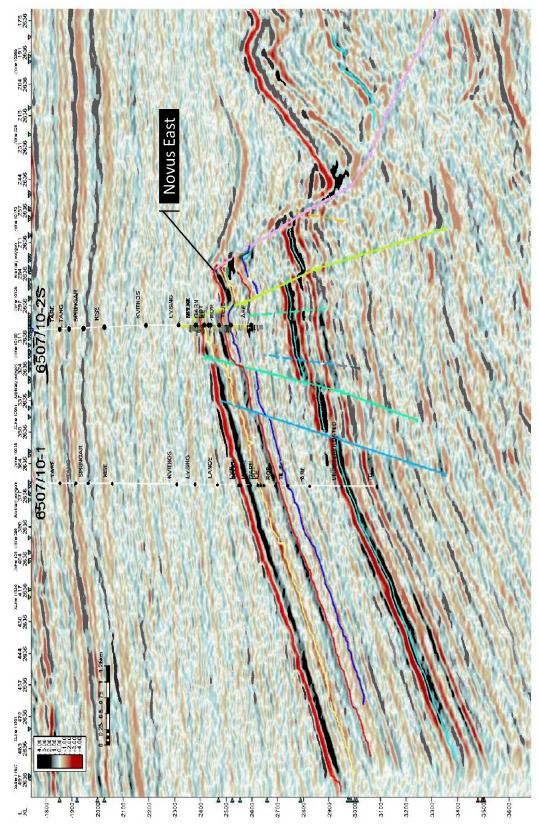


Fig. 4.3 Novus East Structure
Seismic Line through the Novus West Discovery and the Novus East Prospect showing the juxtaposition across the fault.

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Source

Same as for the Novus South Prospect.

Seal

Main seal risk is considerd to be the presence of a competent fault seal between the Garn/Ile formation in Novus East and the water wet Tilje formation in Novus West. Top seal is not considered a risk for the prospect.

## **Novus North Prospect**

The Novus North Prospect has been downgraded and is not considered a prospect. The prospect was originated from a seismic anomaly and this anomaly has changed shape from vintage to vintage of seismic cubes. It is believed the amplitude effect can be caused by a tuning effect.

### **Prospectivity conclusion**

A summary of the risks and volumes for the remaining prospectivity can be found in .

Table 4.1 Volume and risk

	Mm	boe Recove	rable Resou	Risk		
	Mean	P90	P50	P10	POS	Key Risk
Novus East	13,4	3,3	9,59	27,8	0,51	Fault seal
Novus South	35,4	14,00	33,20	60,30	0,22	Seal and Trap

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## **5 Conclusions**

A seismic anomaly was tested by the drilling of the Novus Prospect. Its seismic anomaly proved to be the total accumulation, not only the gas cap as modelled pre-drill. These results have affected the other prospects in the licence in a negative direction when it comes to the volume and economical evaluation. The Novus Discovery itself is too small to be an economical project, but the licence has evaualted if another well could add volumes in the area for a possible development. All licensees conclude that the volumes are too small and a unanimous decision to relinquish the licence on the BOK or drop decision was made.

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## **6** References

6507/10-2 S Novus Discovery Evaluation Report

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