

Relinquishment Report for PL 463S

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1 INTRODUCTION

1.1 License owners

The present license owner was Det norske oljeselskap AS (100%). The license was relinquished 28th of August 2011.

1.2 Award and work program

The license was awarded on the 28th of February 2008 for an initial period of 6 years following the APA Licensing Round 2007. The license is stratigraphic and is awarded for the Post Top Cretaceous interval.

A work program was approved by the authorities on the 29th of February 2008 and the work obligation included:

- Reprocessing of 3D seismic over the entire license within the first 2 years
- Acquire a minimum of 1000km high resolution 2D within the first 2 years
- To make a Drill or Drop decision by 28th of February 2010
- To perform geological and geophysical studies

The license acquired 1000 km high resolution 2D seismic, reprocessed the 3D surveys covering the license and completed work program obligations for the initial period. However, the prospect evaluation could not conclude on a firm drilling decision within the original deadline of 28th of February 2010 and the PL463S applied for a one year extension to be able to come to a recommendation. After a reevaluation of the data it was decided to reprocess part of the southern 3D to generate a PSDM seismic cube. The result was encouraging with increased in data quality and it was decided to do this for the whole license. This new reprocessing could not be finalized with the one year limit and the license applied for an additional 6 month extension in November 2010. This was granted by the Authorities and a new Drill and Drop decision was set to August the 28th 2011. Even with the full reprocessed 3D (DN011M01_PSDM) over the license, it was not possible to mature any prospect to such a degree that it satisfied the requirements for a drilling decision and the license agreed to relinquish PL463S. The authorities were informed about this decision in a letter dated 26th of August 2011.

The license acknowledge the potential in the area, but it was not possible to fully unlock this potential within the current time frame.

1.3 PL463S Prospectivity

PL463S is situated in North Viking Graben in the North Sea. The license is located south of the Valemon - Gullfaks area within the Rugne Sub-basin west of the Huldra gas/condensate field. Fig. 1.1 shows a license map of this part of the Viking Graben focusing on the PL463S.

The focus in the license has been on the whole Tertiary sequence including the Plio-Pleistocene sequences. Fig. 1.2 shows the a detailed stratigraphic column of the Tertiary sequence in this part of the North Sea. Few wells have been drilled in central part of the basin except for the 30/4-1 well situated just south of the license and is a key reference point for the geology in the area. The well contains a few meters of Palaeocene sands together with significant volumes of younger Grid and Skade formations sands.

The lack of significant amounts of Palaeocene sand in this well has been a challenge to the license. The geological model for the Palaeocene sands in the area is linked to a significant western source. This is manifested in the Heimdal, Hermod, Odin and eventually the Frigg sand systems that can be observed on seismic and in the wells further south (Fig. 1.3). In block 30/10 and 25/1, these sand systems can easily be seen and are well developed. North of these blocks, they seems to pinch out although they are present in the Hild Field (Block 29/6,30/4 & 30/7). Further to the west, the development of the Ninian delta on the UK side through the Palaeocene could be another entrypoint for sands into the basin, but there are a intriguing lack of depositional features from the delta front and into the basin not supporting this delta as a significant turbidite source Fig. 1.4. Base on well data in the area, possible plays are illustrated on this seismic line over the central part of the license (Fig. 1.5).

During the initial period of the licence focused on the Miocene sequence looking at the prospectivity involving the Skade sands (which are significant in the 30/4-1 well). This is illustrated in the firste prospect summary chart generated with one Miocene prospect and five leads Fig. 1.6. During the next year significant efforts were put into maturing this into drillable prospects with little success. The seismic data could not reduce the uncertainties to such a level to support a positive drilling decision. In the wake of this work, features where discovered within the Palaeocene sequence and one more prospect was defined (Knabben prospect) (Fig. 1.7). Even though the volumes within the Knabben prospect was at that time significant, the uncertainty could not support a well (Fig. 1.8). Better data was needed to increase the probability of the Knabben prospect as well as being able to mature several of the additional leads found during this work, which formed the basis for the PSDM reprocessing initiative kicked off in 2010.

The work also revealed serious imaging issues below the mobile Oligocene / Eocene shales (Gumbo shale) which needed to be solved before any prospects could be defined in this part of Tertiary. The effect of this unit on the seismic is illustrated in the following figure with a west-east line through the central part of the license (Fig. 1.9). To make an effort to solve these imaging issues a PSDM reprocessing project was initiated, but as this work progressed, it became clear the more time was needed to make a full evaluation of the prospectivity of the area based on the new data. An application for a 6 month deferral of the drill or drop decision was filed to the Authorities in November 2010 and a deferral was granted by the Authorities 1st of December 2010.

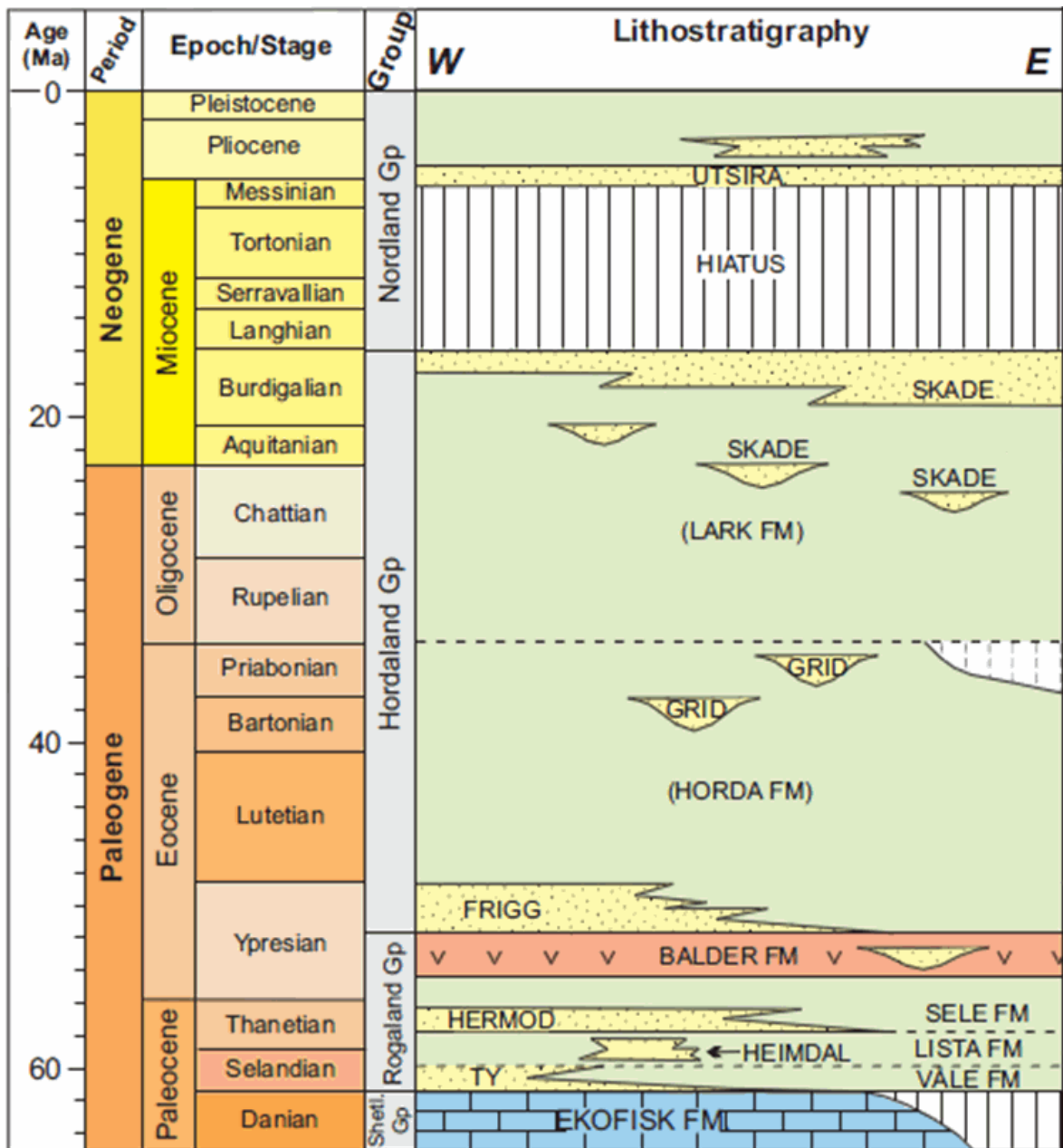


Fig. 1.2 Lithostratigraphy of Tertiary

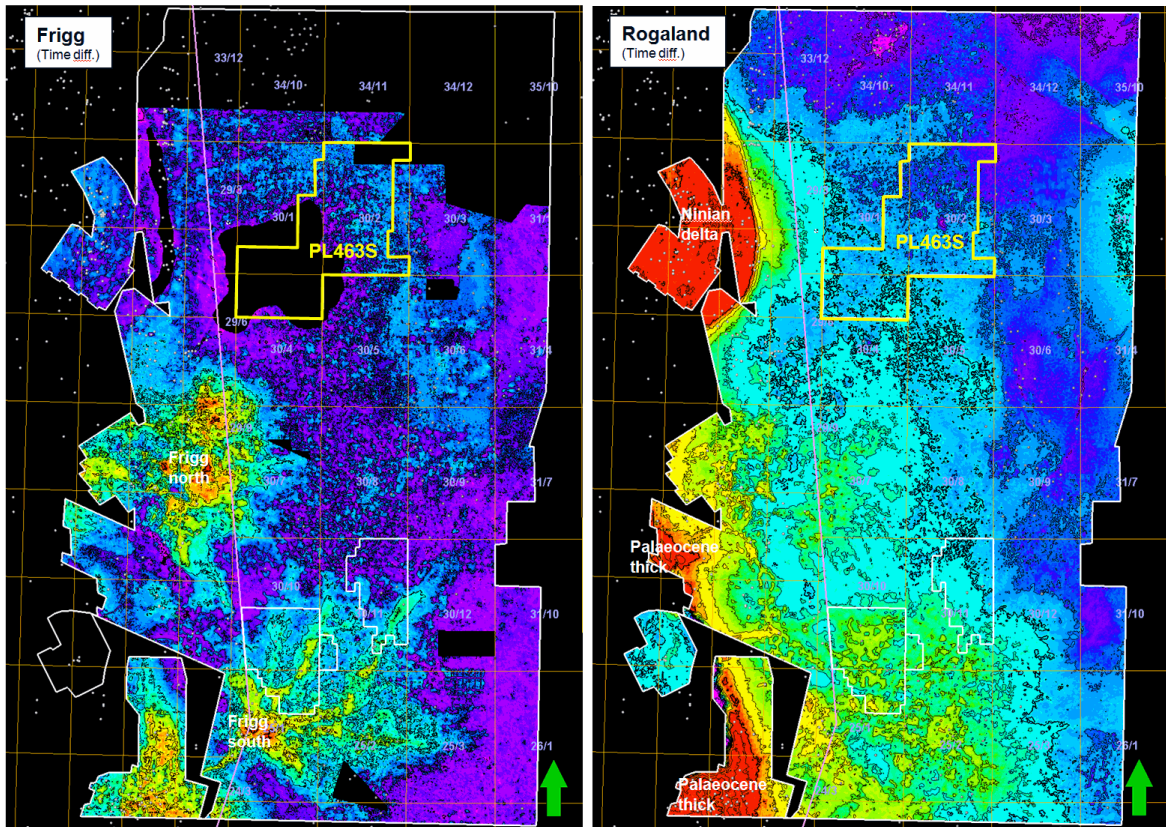


Fig. 1.3 Frigg Formation and Rogaland Group Isochores. To the left, Frigg Formation time isochore shows the two main Frigg depositional systems with few indications of reaching the license. To the right, the Rogaland Group (Palaeocene) time isochore with the southern system display a gentle wedge with decreasing thickness into the basin. Whereas west of the license, the Ninian delta has steep wedge that could indicating the presence of sedimentary processes restricting transport of sediments into the basin.

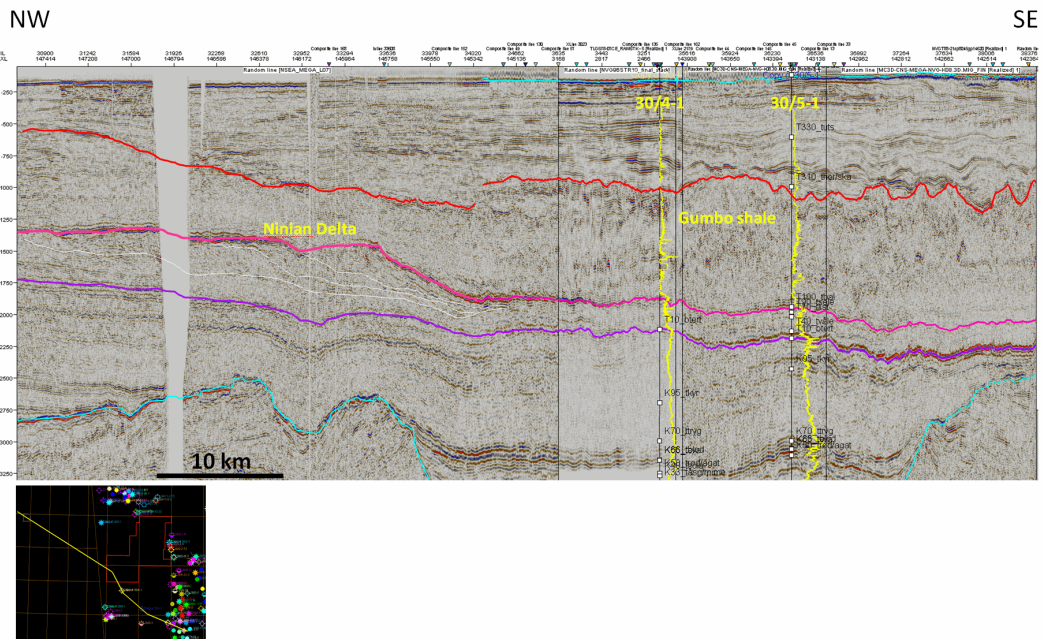


Fig. 1.4 Seismic W-E section. Seismic section from west to east over the Ninian delta and into basin though well 30/4-1 and 30/5-1. The very steep delta front is easily visible together with the prograding and steeping of the front from west to east. The horizons are from the bottom: Base Cretaceous= Blue, Base Tertiary= purple, Top Balder fm.= deep red and Top Gumbo= red

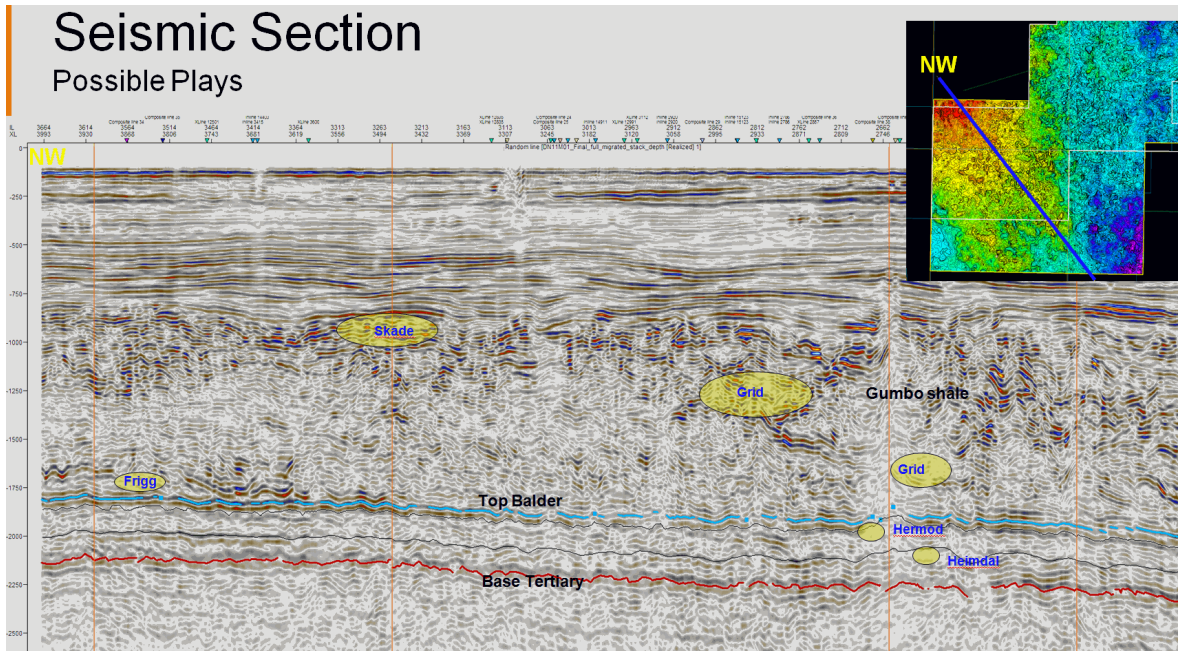
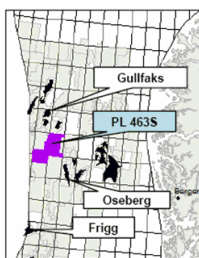


Fig. 1.5 PL463S Play concepts. This seismic line illustrate the possible plays that could be present in the license. The deep Palaeocene plays are linked to the presence of Hermod or Heimdal sands. For the younger units, Gridd and Skade is the most likely to be present, but Utsira and Naust cannot be ruled out. In these shallow units, biogenic gas or heavy biodegraded would be the HC case which will impact the economics.



Awarded : APA 2007, 29.02.2008
Valid to : 01.03.2014
Work Program : Reprocess 3D seismic within 2 years
 2D survey within 2 years
 Drill or drop within 2 years
 BOV within 4 years
 PDO within 6 years
Licensees : Det norske 70% (operator)
 Aker Expl. 30%
Voting Rules : 2 companies and minimum 50%
Water Depth : 125 m
Drilling Plans:

Exploration / Appraisal wells:
 25/2-10 S 1985 TD 2967 m RKB, Oil and gas in L. Miocene Skade, minor amounts of gas and oil in Frigg Fm.
 25/2-11 1987 TD 2075 m RKB, hydrocarbons in L. Miocene Skade and top Frigg Fm.

PL 463S		GROSS RECOVERABLE RESERVES / RESOURCES								
		Low	Base	High	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)
CATEGORY	RESERVOIR LEVEL	HC	RF (%)	POS (%)	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)
PROSPECTS										
	Blåfjell	L. Miocene	oil	30	17	2,28	4,71	10,8		
LEADS										
	Kobberdøkkfjellet	L. Miocene	oil							
	Hoggfjellet	L. Miocene	oil							
	Tverken	L. Miocene	oil							
	Bjørnåsen	U. Miocene	oil							
	Solbergfjellet	U. Miocene	oil							
	Knabben	Eocene	oil							
	Storsteinsfjellet	Paleocene	oil							
	Solbergvarden	Pliocene/ Pleistocene	gas							

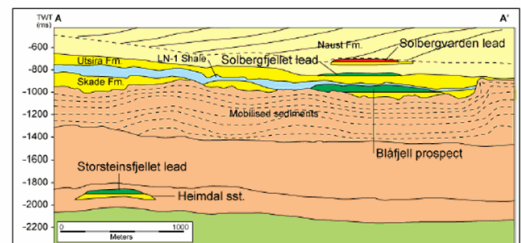
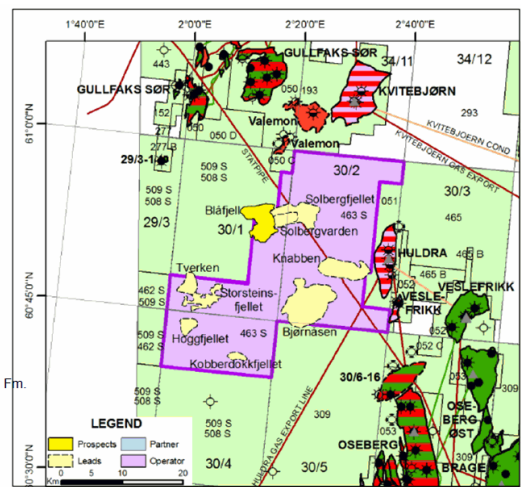
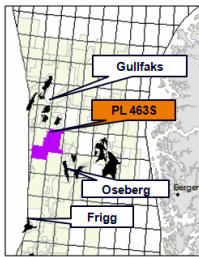


Fig. 1.6 License Summary 2009. This early version shows several prospects and leads of Miocene age in addition to Palaeocene and younger features.



Awarded : APA 2007, 29.02.2008
Valid to : 01.03.2014
Work Program : Reprocess 3D seismic within 2 years
 2D survey within 2 years
 Drill or drop within 2 years
 BOV within 4 years
 PDO within 6 years
Licensees : Det norske 100% (operator)
Voting Rules :
Water Depth : 125 m
Drilling Plans :

Exploration / Appraisal wells:

25/2-10 S 1985 TD 2967 m RKB, Gas in Miocene sands, minor amounts of gas and oil in Frigg Fm.
 25/2-11 1987 TD 2075 m RKB, hydrocarbons in both Miocene and Frigg Fms.

PL 463S		GROSS RECOVERABLE RESERVES / RESOURCES								
		Low		Base		High				
CATEGORY	RESERVOIR LEVEL	HC	RF (%)	POS (%)	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)
PROSPECTS										
Blåfjell	L. Miocene	oil	0,3	17	0,182		15,15		151,2	
Knabben	Paleocene	oil	0,4	11	7,6		40,4		113,6	
Knabben	Paleocene	Gas	0,4	11		3,19		18,06		53,06
LEADS										
Skade lead 1	L. Miocene	oil								
Skade lead 2	L. Miocene	oil								
Skade lead 3	L. Miocene	oil								
Utsira lead 1	U. Miocene	oil								
Utsira lead 2	U. Miocene	oil								
Paleocene lead	Paleocene	oil								
Naust lead	Pliocene/Pleistocene	gas								

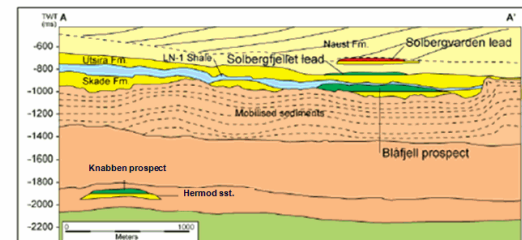
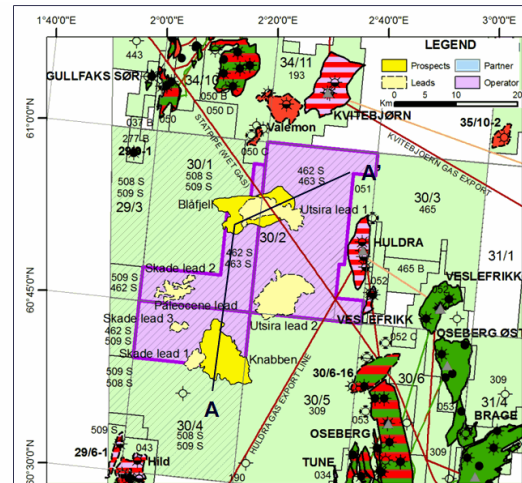
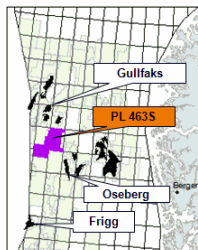


Fig. 1.7 License Summary 2010. The updated license summary shows a renewed focus on the Palaeocene sequence with the definition of the Knabben prospect.

PL 463S, Blocks 30/1, 2 and 4



Awarded : APA 2007, 29.02.2008
Valid to : 01.03.2014
Work Program : Reprocess 3D seismic within 2 years
 2D survey within 2 years
 Drill or drop within 2 years
 BOV within 4 years
 PDO within 6 years
Licensees : Det norske 100% (operator)
Voting Rules : 2 companies and minimum 50%
Water Depth : 125 m
Drilling Plans :

Exploration / Appraisal wells:

25/2-10 S 1985 TD 2967 m RKB, Gas in Miocene sands, minor amounts of gas and oil in Frigg Fm.
 25/2-11 1987 TD 2075 m RKB, hydrocarbons in both Miocene and Frigg Fms.

30/8-2 has significant development of Hermod Fm. Sands

PL 463S		GROSS RECOVERABLE RESERVES / RESOURCES								
		Low		Base		High				
CATEGORY	RESERVOIR LEVEL	HC	RF (%)	POS (%)	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)	Oil (MSm ³)	Gas (GSm ³)
PROSPECTS										
Knabben	U. Palaeocene	oil	0,4	15	26,4		42,3		61,0	
Knabben	U. Palaeocene	Gas	0,7	15		11,2		17,9		25,7
LEADS										
Skade lead 1	L. Miocene	oil								
Skade lead 2	L. Miocene	oil								
Skade lead 3	L. Miocene	oil								
Utsira lead 1	U. Miocene	oil								
Utsira lead 2	U. Miocene	oil								
Blåfjell	L. Miocene	oil	0,3	10	6,4		17,4		35,6	
Naust lead	Pliocene/Pleistocene	gas								

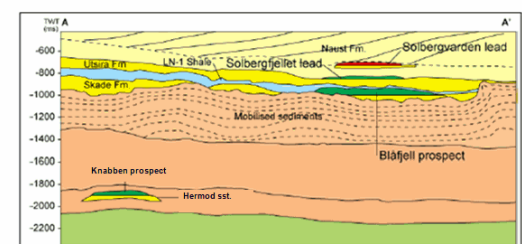
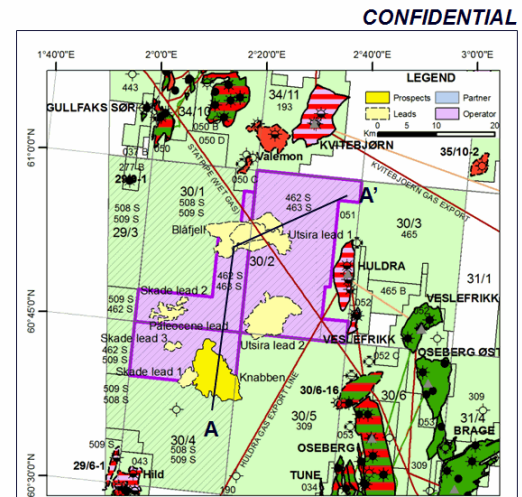


Fig. 1.8 License Summary Q3 2010. This updated license summary took into account the first PSDM data that was generated on smaller area over the Knabben prospect.

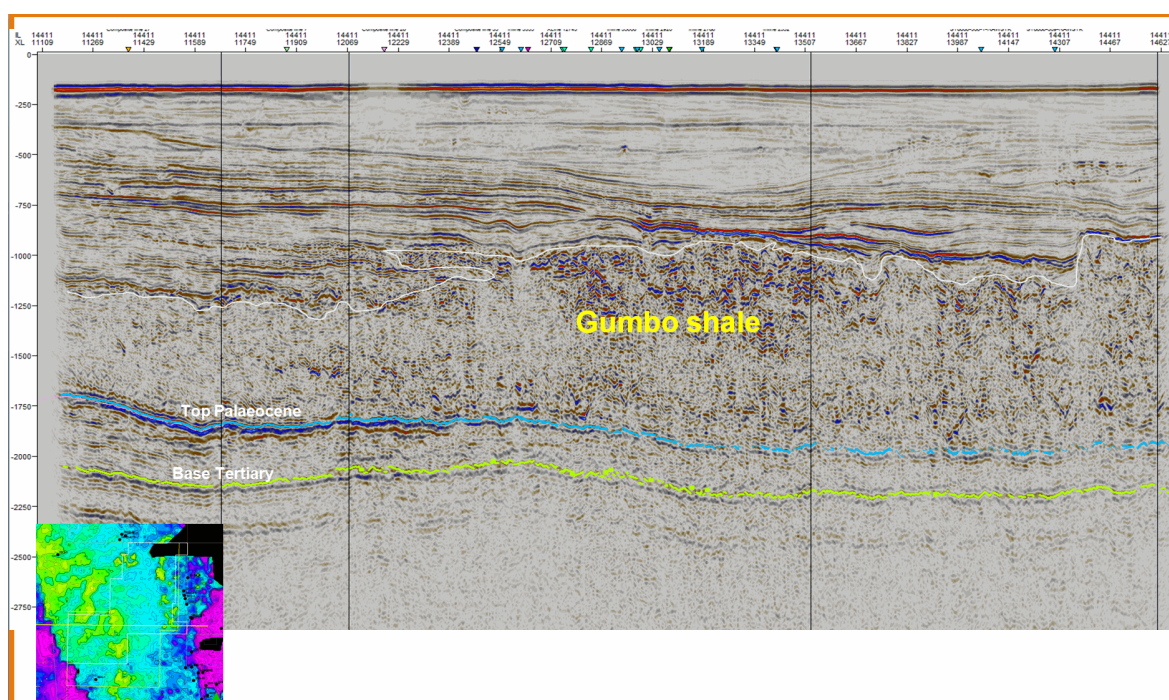


Fig. 1.9 Seismic section inline 14411 (NX10M02). *The Gumbo shale display a significant seismic complexity where heterogeneities (such as sandstones, limestones, calcareous mudstones, etc) introduce a lot of velocity and density contrasts that generates a very chaotic seismic picture. Intra Gumbo Grid sands could have the potential to be prospective, but better seismic is needed.*

The new data was received early in June 2011. There was an improvement from the older data, but the seismic imaging of the Palaeocene could not de-risk the Knabben prospect to such an extent that a positive well decision could be made. Neither of the other prospects or leads were able to support a drilling decision and it was decided to relinquish the license. The operator recognizes the potential in the area and is continuously working on the issues to improve the seismic. Progress has also been made in the understanding of the Gumbo shale and effect it has on the prospectivity (Grid and Skade formation sands).

2 DATABASE

2.1 Seismic database

In the this part of the Viking Graben, several 3D's are available together with a significant amount of 2D surveys (Fig. 2.1). The quality varies considerably between the different 2D surveys as well as between the 3D surveys. This quality difference is both age related and related to special geological conditions in the area.

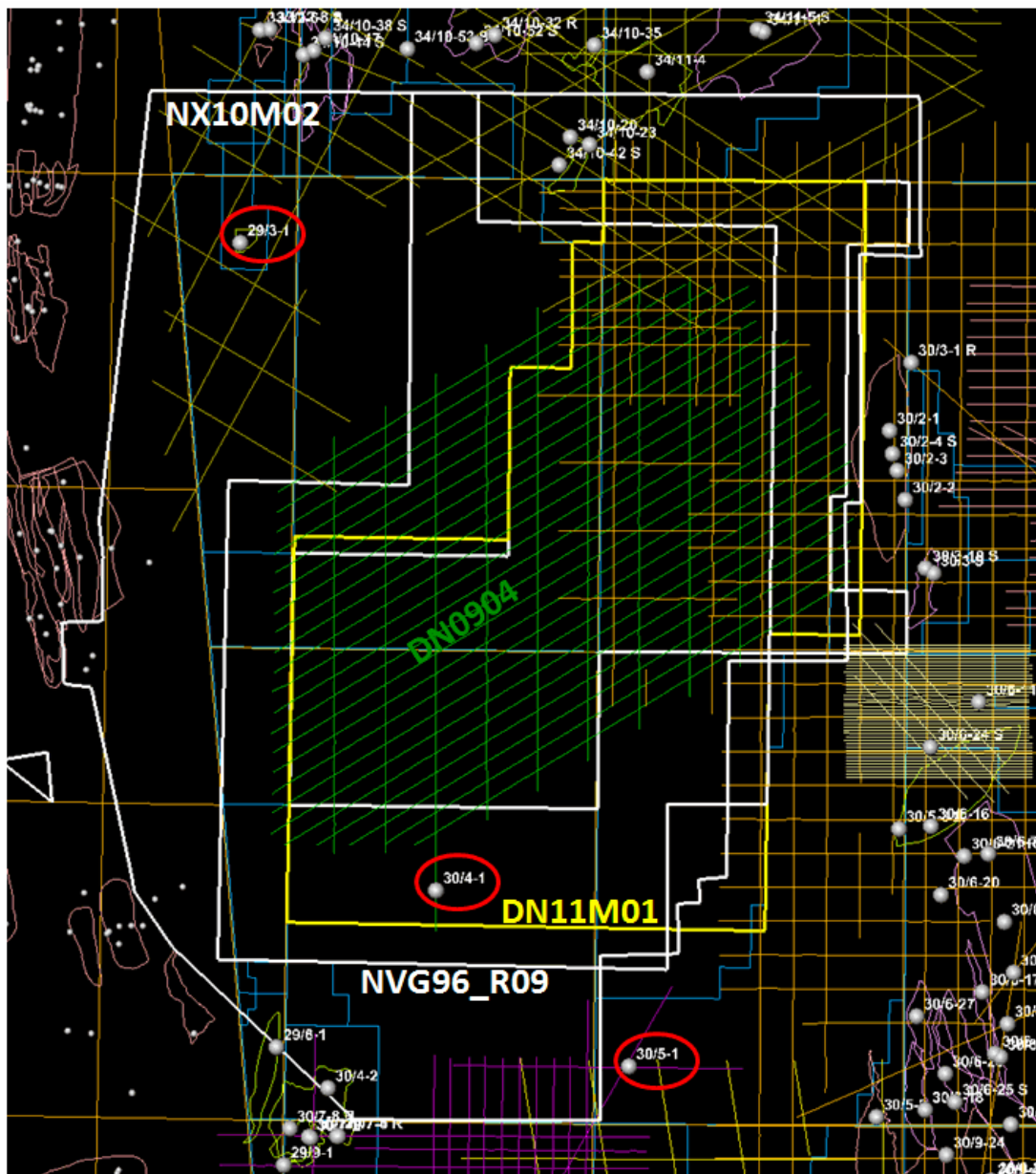


Fig. 2.1 Seismic database

The PGS megamerge made the basis for the first interpretation in the area. As part of the work program, a high resolution 2D survey (DN0904) was acquired and interpreted. Based on these data and the NVG96_R09 3D survey, it was recognised that higher quality 3D data was needed. A test PSDM processing of the NVG96_R09 was conducted in 2010 over the southern part of the license to see if any image improvement could be obtained. A marked improvement was observed and a larger PSDM processing project including the whole license was initiated late in 2010 with data deliverance in Q2 2011 (DN11M01).

In addition to this new survey, the license had access to the NX10M02 PSTM survey (merge of NX0901, NX0902 and NX0803) acquired by Nexen over PL508S and PL462S licenses which therefore also covered most of PL463S. Det norske as partner in these licenses, had access to these data.

This together with the full PSDM processed DN11M01 (reprocessing of NVG96_R09) a reasonable picture of the Palaeocene sequence could be obtained although there were issues with respect to sub Gumbo imaging that was not solved with the current data. The surveys used in the evaluation is shown in Fig. 2.2.

Surveys	Year	Area (sq.km. of 3D surveys)	Operator/Comments
NVG96	1996	2752	Public
ST9207	1992	570	Statoil/Public
ST8720R93	1993	553	Statoil/Public
TFE-91	1991	920	TotalFinaElf/Public
NX10M02 PSTM	2010	3085	Nexen
NVG96R09	2009	1650	Detnorske
NVG96STR10	2010	450	Detnorske
NVG96STR10PSDM	2010	450	Detnorske
DN11M01 PSDM	2011	1450	Detnorske
PGSmega-L08	2008	3110	PGS/Public
		2D Surveys	
DN0904	2009	3000km	Detnorske

Fig. 2.2 Seismic surveys used in the evaluation

2.2 Well data

Quite a number of wells have been drilled in the vicinity of the license, but very few within the graben itself. The wells are scattered around the license on structural highs except for a couple of wells that are situated within the basin (29/3-1, 30/4-1 and 30/5-1). The location of the most important well-locations are shown on map Fig. 2.3. A list of the wells in the common database is also presented in Fig. 2.4.

The few datapoints close to the license show the presence of little Palaeocene sands. On the other hand, they have significant amount of sand in the Eocene and younger sequences. Due to the lack of good sand indicators in the main prospective intervals that can be observed further south (Frigg, Hermond and Heimdal sands), a big effort was put into understanding

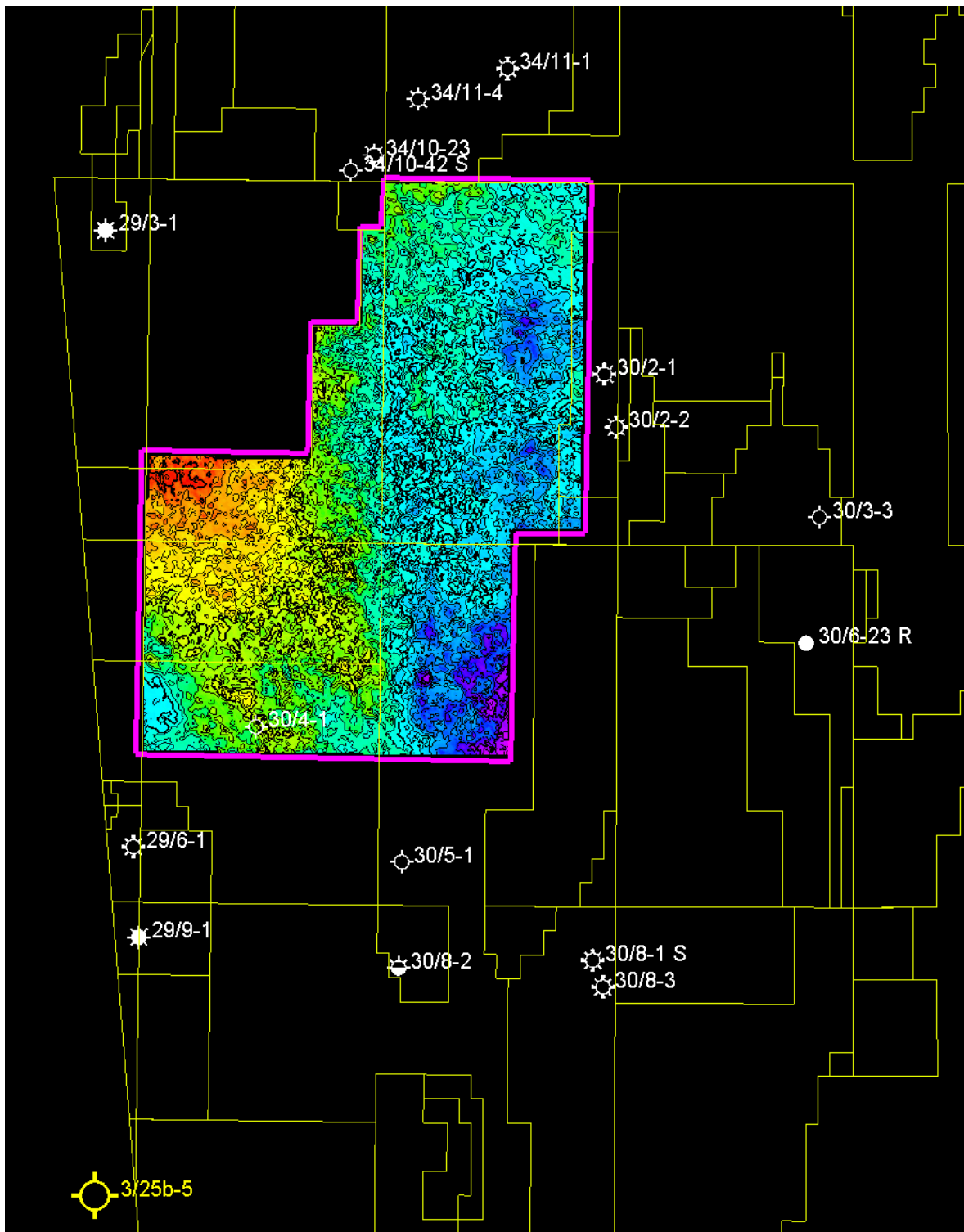


Fig. 2.3 Well location. The map shows the location of most of the wells used in the evaluation of the license.

Well name	Operator	TD	Log data	Biostratigraphy	
				Source	Year
29/3-1	Total	4427		RRI	1986
30/2-1	Statoil	4243	Aceca	Paleocservices PGS	1983 1986
30/2-2	Statoil	4170	Aceca	Paleocservices	1985
30/3-3	Statoil	3419	Aceca	RRI	1983
30/4-2	BP	4800	Aceca	BP RRI	1980 1989
30/5-1	Statoil	4124	Aceca	Shell Diesen, G.W. RRI	1974 1984 1998
30/6-24S	Norsk Hydro	3986	Aceca	RRI	1991
30/8-2	Norsk Hydro	2405	Aceca	Stratlab	1995
33/12-7	Statoil	3703	Aceca	Stratlab	1989
34/10-23	Statoil	4764	Aceca	Paleocservices	1985
34/10-35	Statoil	4310	Aceca	Geostrat	1992
34/10-42S	Statoil	4520		Geostrat	1999
34/11-1	Statoil	4580	Aceca	Geostrat	1994
34/11-3	Statoil	4482	Aceca	Geostrat	1997
34/11-4	Statoil	4438		Geostrat	1999
35/10-1	Statoil	3986	Aceca	Paleoservices	1992
35/10-2	Statoil	4677	Aceca	Geochem	1996

Fig. 2.4 Well list. A list of the wells used in the evaluation of the license.

the development of the Palaeocene in the area in order to increase the prospectivity. Minor Heimdal sands in the 30/4-1 well are encouraging, but they most likely represent the very distal part of the larger sandy system to the west. The key issue to generate Palaeocene prospects in the licence was to have a viable depositional model that transported sand into this part of the basin. The presence of Grid and Skade sands in this well increased the search for prospectivity at this stratigraphic level.

2.3 Special studies

The main challenge in defining the prospectivity is the seismic imaging, i.e. the ability to see within and below the Gumbo shale. The presence of sandy reservoirs with good quality in the Grid and Skade units are evident from wells in the area, but to define these possible prospects is a challenge especially with respect to the Grid sands situated within the Gumbo shale. If we look at the different surveys, the poor quality of the seismic is evident and the incremental increase in quality that has been obtained in the different reprocessing projects can be seen in following figures Fig. 2.5, Fig. 2.6. The initial reprocessing gave a better resolution and imaging of the post Gumbo units with more details in the Skade and Utsira sequences. Whereas for the Gumbo itself and the Palaeocene below, the imaging was still poor with no seismic response in some places.

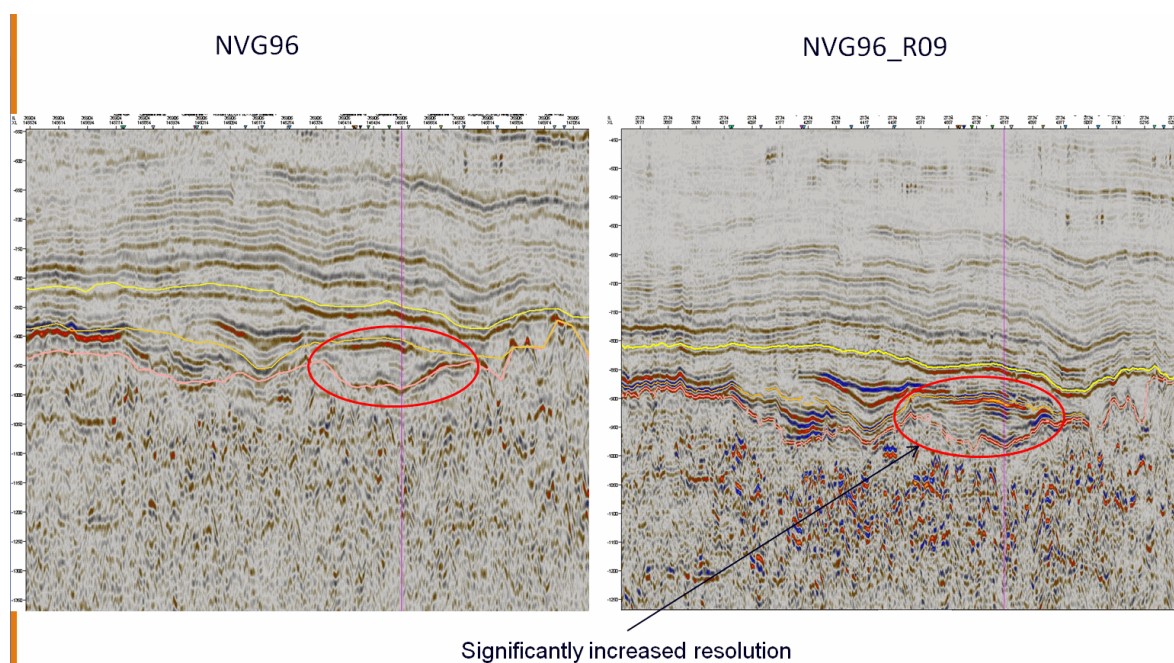


Fig. 2.5 Original seismic to first reprocessing. From the original NVG96 to the NVG96_R09 there is a significant improvement above the Gumbo, but still there are problems below.

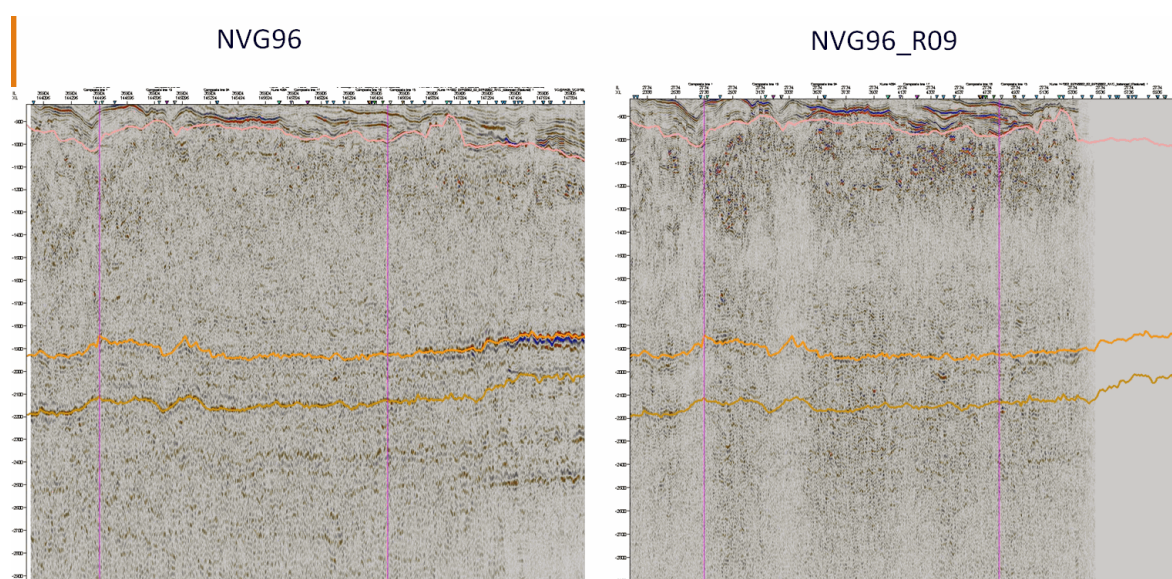


Fig. 2.6 NVG96 vs NVG96_R09. The sub Gumbo imaging did not improve in this process even though the seismic above improved.

A special study was therefore initiated to focusing on the intra and sub Gumbo units. The first pas was on a small seismic cube over the southern part of the license including the 30/4-1 well. This PSDM test processing used the NVG96 survey (later combined with data from the ST9710, 9818, 9801 & 8720 surveys) and a significant improvement was obtained in the sub Gumbo section. Encourage by the results from this work and with some new ideas, the license decided to reprocess the whole area. This was done in the spring of 2011 parallell with interpretation on the existing PSTM and PSDM surveys.

The reprocessing was done by ION-GXT who used a "SWDnoise" to attenuate acquisition noise. A survey matching was then applied to produce a singel dataset with consistent character from the five surveys used. The method used in the final processing was Pre-Stack Depth Beam migration using the final depth velocity model (four passes of gridding tomopraphy). To speed up the entire project, non-regularised gathers were Kirchhoff pre-stack depth migration in iteration 1 and 2 of the velocity model building stage. The final version of the data displayed a significant improvement with respect to the Palaeocene, but still there are a lack of continuity in both the Gumbo and Palaeocene sequences in some areas. Even so, looking from the NVG96-R09 through the NVG96STR10 to the final DN11M01, we can see a significant improvement in resolution and seismic quality (Fig. 2.7). The time efficient method used have a negative effect on the seismic amplitudes which cannot be fully used in the seismic studies.

In the lower part of the Gumbo, just above the Balder Formation, indication of injections sands can be observed on the seismic. These highly dipping events occurr above Top Balder Formation and in the lower part of the Gumbo shale (as well as within the Gumbo itself) (Fig. 2.8). These are most likely related to injection of Grid sands and could be part of the problem with imaging of the deeper units. The presence of these injectites could be of prospective interest if they have enough volume potential.

For the intra Gumbo resolution, more complex and time consuming PSDP methods have to be used to preserve amplitudes and increase the lateral and vertical resolution, but this was not possible within the current drill or drop deadline.

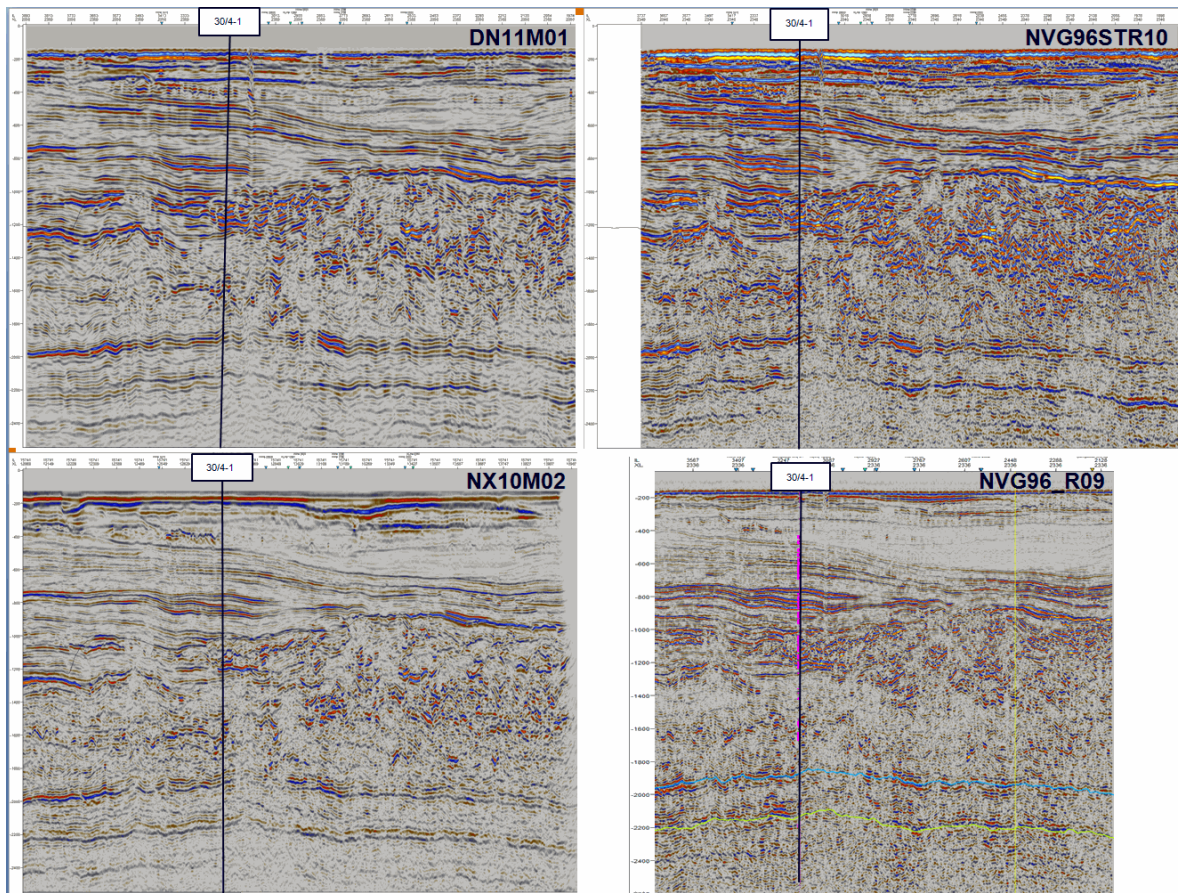


Fig. 2.7 Surveys illustrating quality improvement. The best PSTM survey is the NX10M02, but even here there are still limited resolution within the Palaeocene package (between blue and green horizon, NVG96_R09). The two upper most surveys are PSDM processed and the final version (DN11M01, beam migration method) have good quality, but still there are room for improvements.

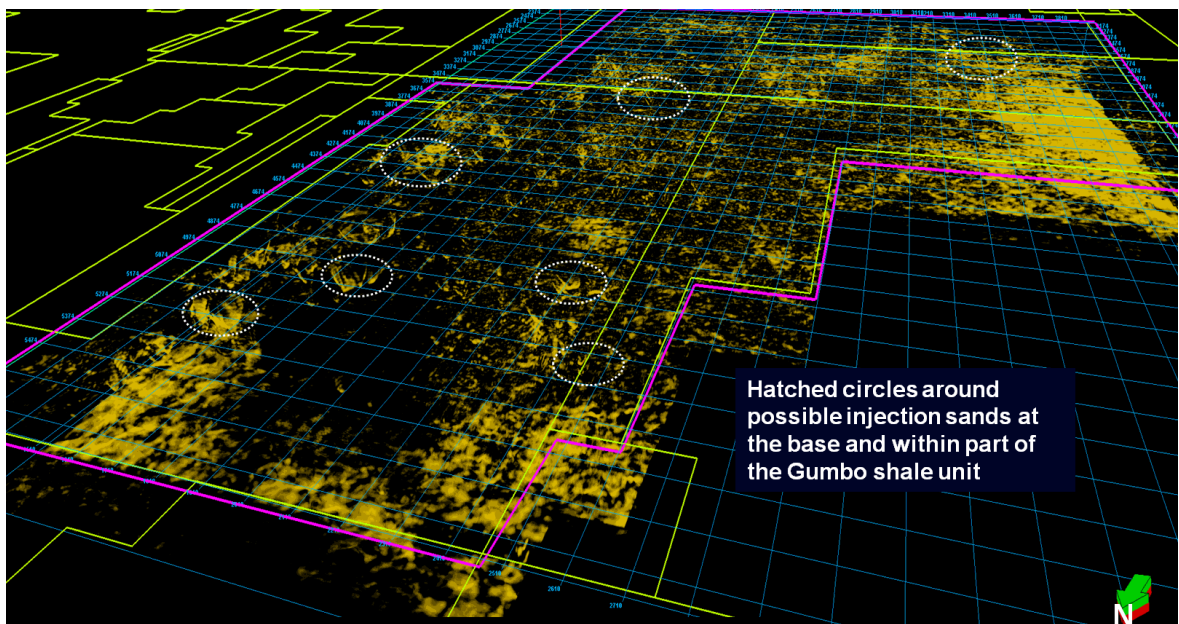


Fig. 2.8 Possible injection sands. Viewed from the north towards the SSE, a partly transparent seismic volume display the characteristics of injection sands, the seagull wings (white hatched circles). A 500mstwt window is displayed in 3D where the strong amplitudes are in yellow.

AVO STUDY

Based on 30/5-1 well a clear seismic response was anticipated within the shallower Skade and Grid sands based on fluid content (Fig. 2.9). The AVO response is not significant, but the fluid response should make it possible to separate between water/heavy oil and gas. The challenge is that at these shallow levels, the difference between heavy oil and water is minor and hard to detect, whereas gas will give a good response (Fig. 2.10).

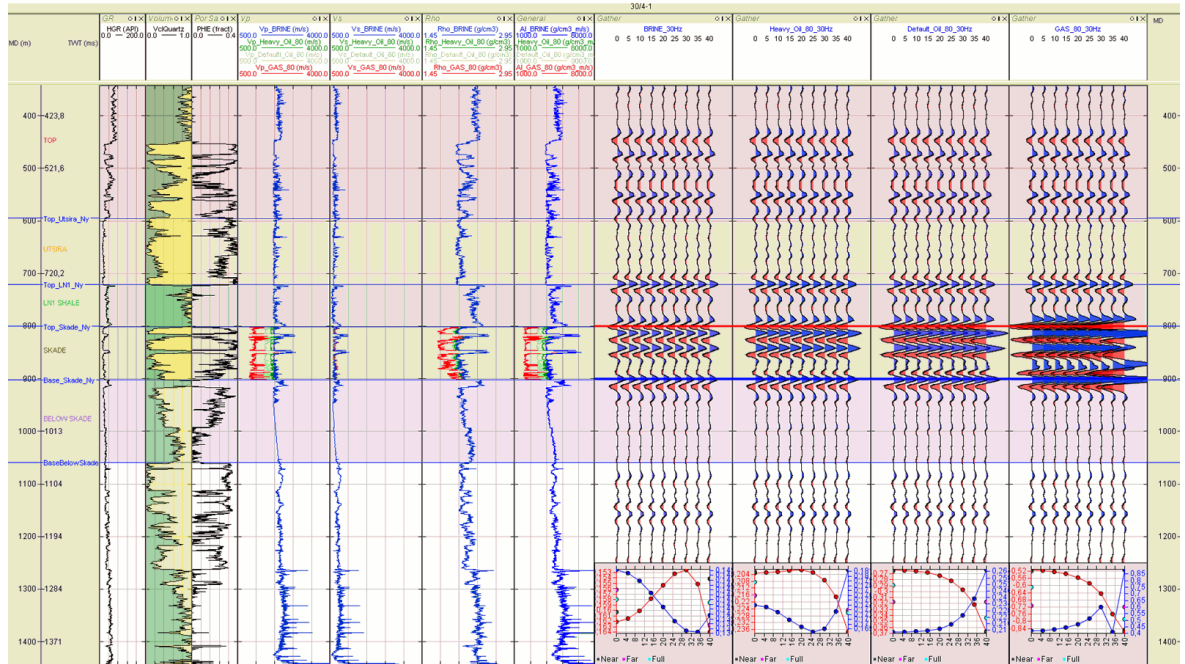


Fig. 2.9 Well 30/4-1. Petrophysical interpretation of the 30/4-1 well close to the license. Good fluid response can be observed in the Skade formation and is also anticipated within the Grid sands. This indicate that sands with light oil or gas should brighten up on the seismic.

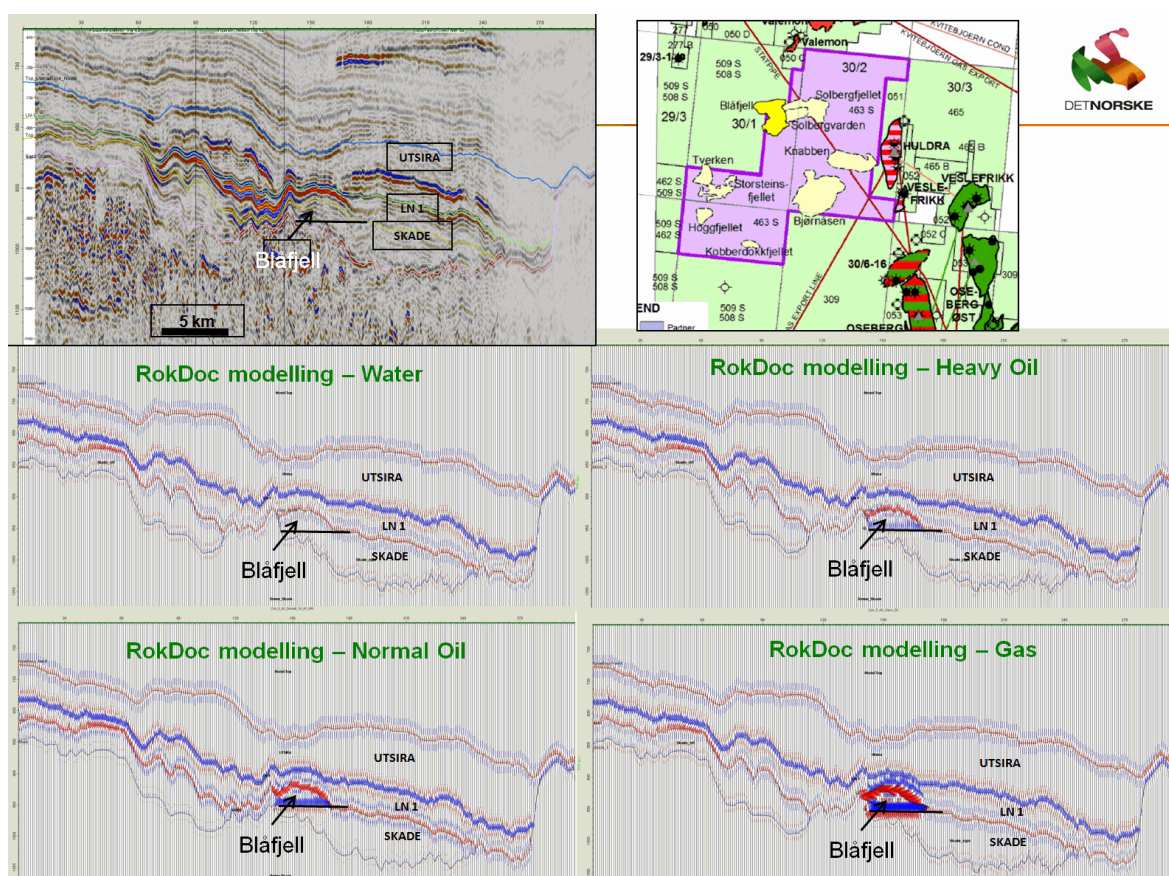


Fig. 2.10 AVO model at the Blåfjell lead. Based on the petrophysics from the 30/4-1 well, this Blåfjell lead model indicate that a gas filled Blåfjell should be different from a water filled. On the seismic, no owc or goc is observed lowering the propability for a prospect at this location.

Experiences from discoveries made further south indicates that the same effect should be observed within the Palaeocene sands, but the poor seismic in this area makes this a difficult task if not impossible.

DEPOSITIONAL MODELS

There are well defined depositional models for the Palaeocene in most parts of the North Sea and these have been the basis for our models. Moving into the southern part of the North Viking Graben we have strong indications that we are in the distal part of deltaic systems developing in the west. New work done in wells in the area increased our resolution and we have together with the ongoing seismic interpretation established possible new sand fairways for the Palaeocene .

Most wells in the area have Grid and Skade sands in the post Balder sequence (Eocene to Micoene). Due to the mobilised Middle Eocene to Lower Oligocene shales, depositional patterns are hard to establish. There seems to be an increasing input of coarser material from the west through this periode from the more confined Grid and Skade sand systems to the widespread Utsira Formation. The deposition of the Skade sands are in part controlled by and possibly also controlling to some extent the movements in the underlying shales (Fig. 2.11).

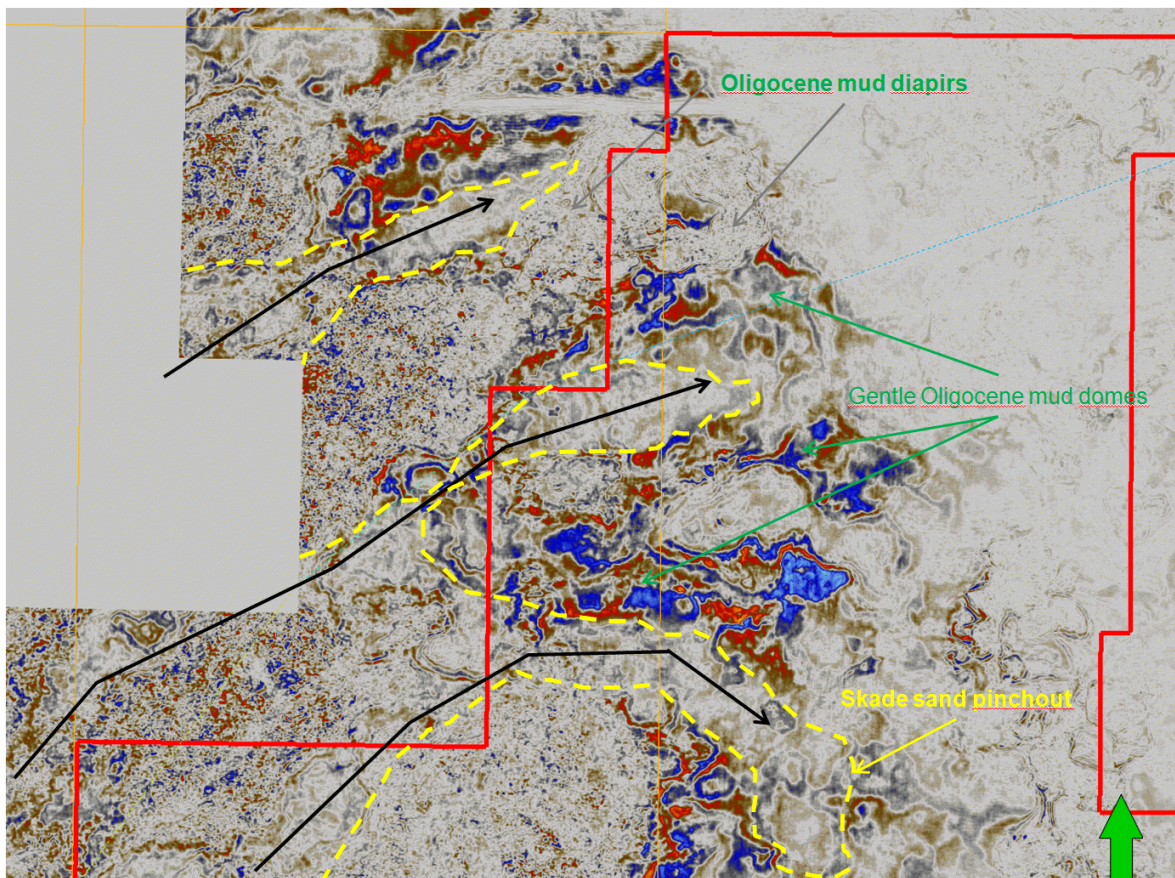


Fig. 2.11 Shallow timeslice through Skade Formation. This timeslice through the Skade and Gumbo system display the interaction between northeast prograding Skade sand fairways and the mobilised and mounding Gumbo shales.

3 PALAEOCENE PROSPECTIVITY

The most sandy Palaeocene units occur to the south and west of the license. From early-middle Palaeocene (Heimdal sst) several deltas are prograding eastward from the East Shetland Platform and out into the basin. This overall depositional setting continues up to the very profound Frigg systems above the Balder tuffs (Fig. 3.1, Fig. 3.2). The present work has been concentrating on understanding the sand distribution in the area during this time and to defining possible 4-way closures as well as stratigraphic traps and combination of these.

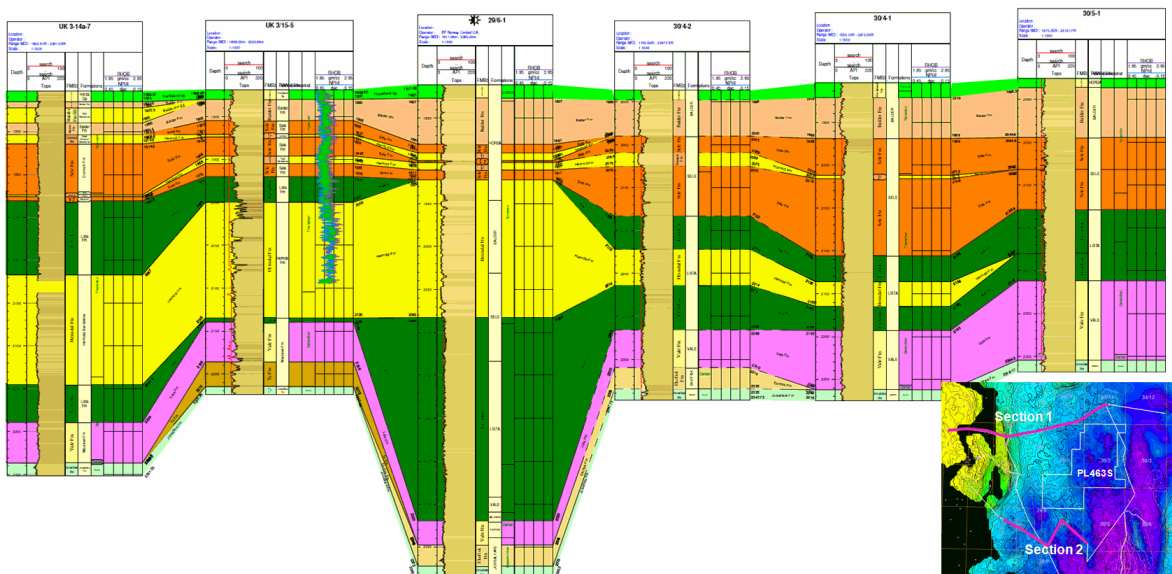


Fig. 3.1 West-East well correlation Section 2. This well correlations section shows the sand (in yellow) development from the west with thick sandy unit to where they shale out in the basin. The map shows the location of both sections.

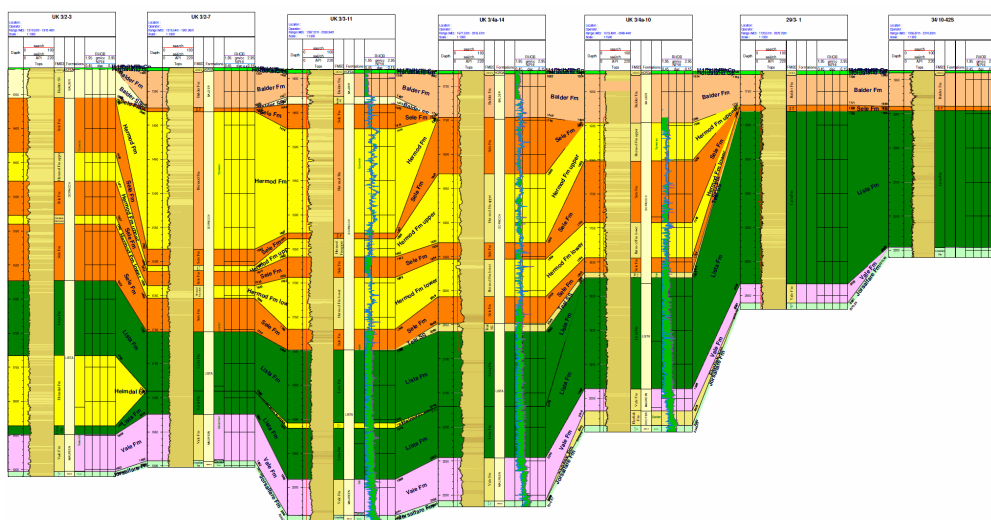


Fig. 3.2 West-East well correlation Section 1. This section shows the thick Hermod sequence associated with the Ninan delta in the west and how rapid the units shales out towards the east and well 29/3-1. See last figure for section location.

The dominant sand source is from the western through most of the Tertiary as shown on this regional seismic line (Fig. 3.3). This line also illustrates the lack of consistent seismic response within the Gumbo shales where seismic events only can be traced for short distances. In some area, only a bundle of seismic features can be traces for certain distances which makes it difficult define other than leads within the Gumbo shale.

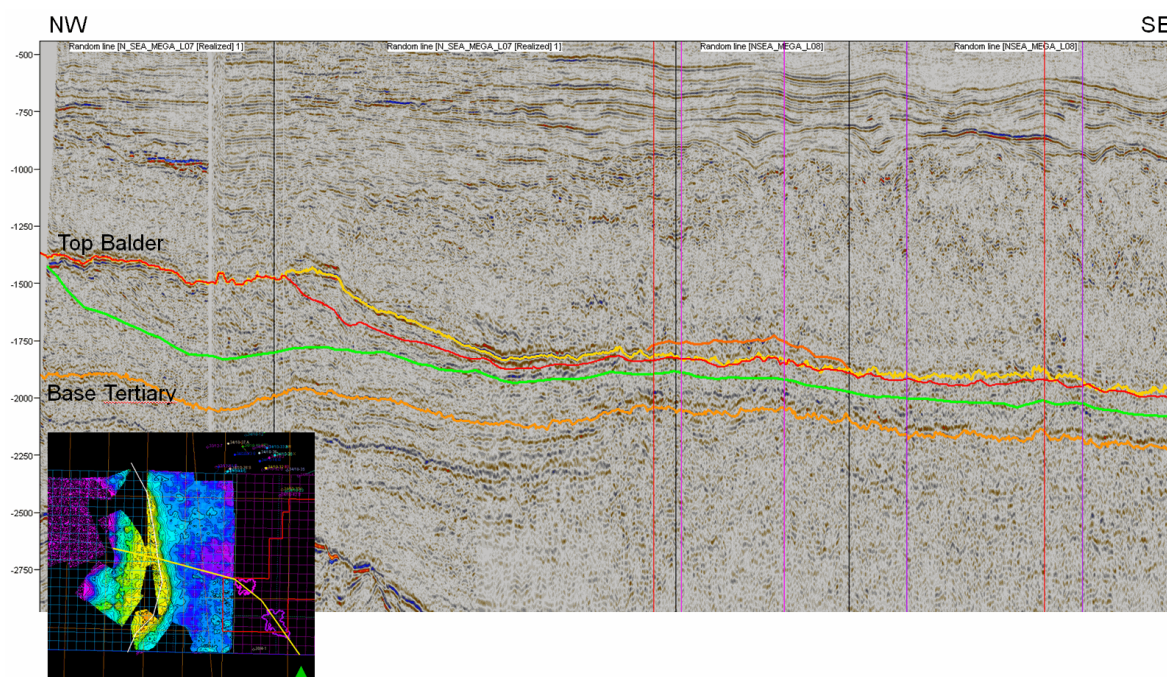


Fig. 3.3 West-East semi regional seismic line. *This line, going from the late Palaeocene Ninian delta to the west towards the east, illustrates the general trend of the western sediments source.*

The topographic relief on Top Balder display a gentle NW to SE to E dipping surface with several 4-way closures and these together with structures at Skade and Grid Formations, defines the potential in the license (Fig. 3.4). In general, the main prospectivity is related to the presence of Heimdal or Hermod Formations depending on which sand could be present. An observation from the discoveries to the south is that the hydrocarbons tend to migrate to the uppermost sands so that stacked Palaeocene reservoir systems are very rare. From the well correlations shown above, it evident that there is an abrupt decrease in sands being transported into this ara from the west and an easterly source is hard to predict.

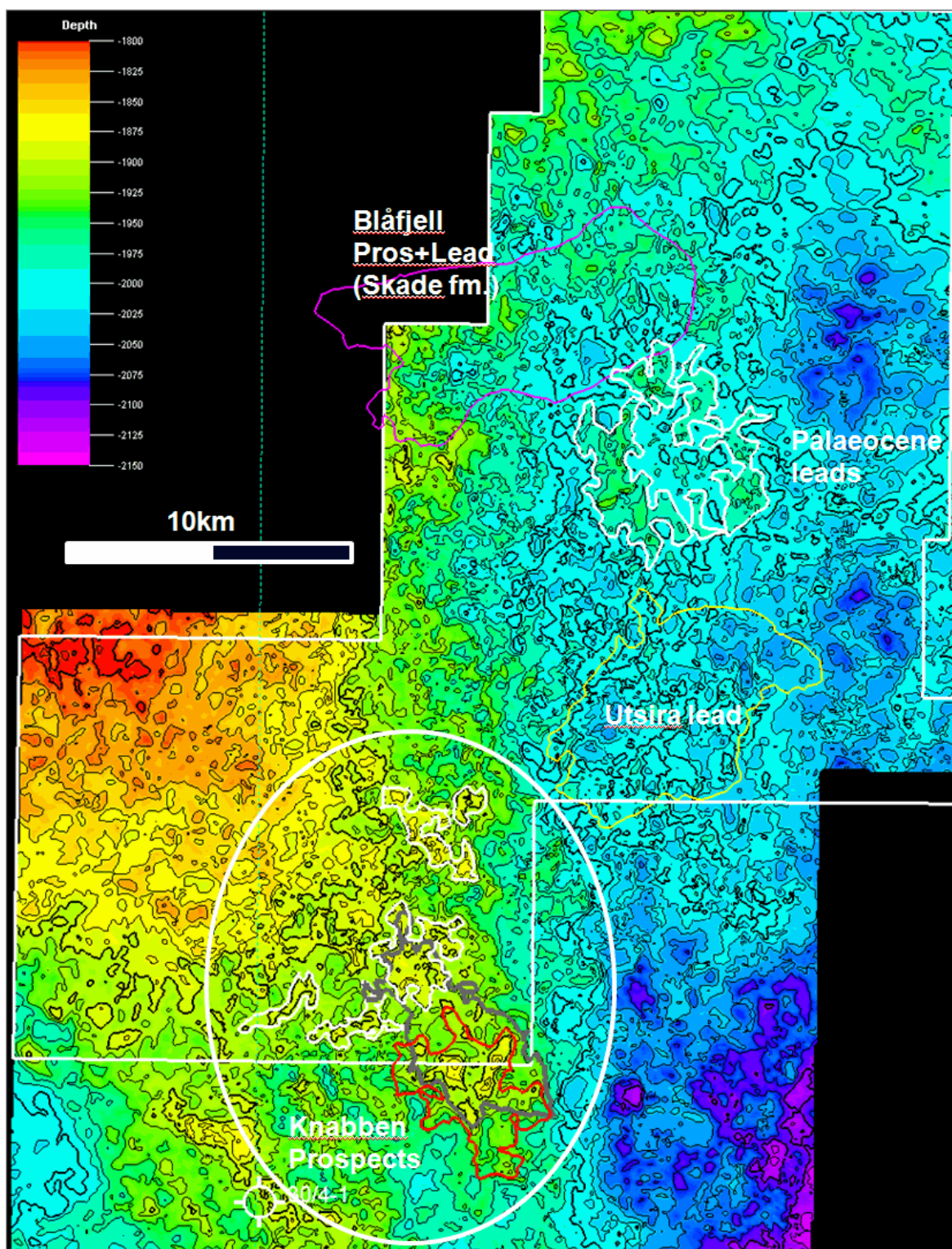


Fig. 3.4 Top Balder Formation with prospects and leads. The main prospects and leads shown on the top Balder map. Palaeocene features is shown as white grey and red outlines.

3.1 Knabben Prospect

The Knabben prospect on the new data has lost much of its 4-way closure area compared to the original data. On the DN011M01 PSDM data it now comprises a set of smaller closures and this could also be caused by velocity complexities in the overburden (Fig. 3.5). The volume potential for the largest of these closures (at top Lista level) is limited as shown in Fig. 3.6. The same complex pattern of 4-way closures can also be observed at top Balder reducing the level of confidence in the trap. This has reduced the overall probability for the Knabben prospect as well as reducing the former robust 4-way closure volumes. Now some of the largest structures are in the northern part of the license where the probability for sands are less than 20% which reduces these to leads (Fig. 3.7).

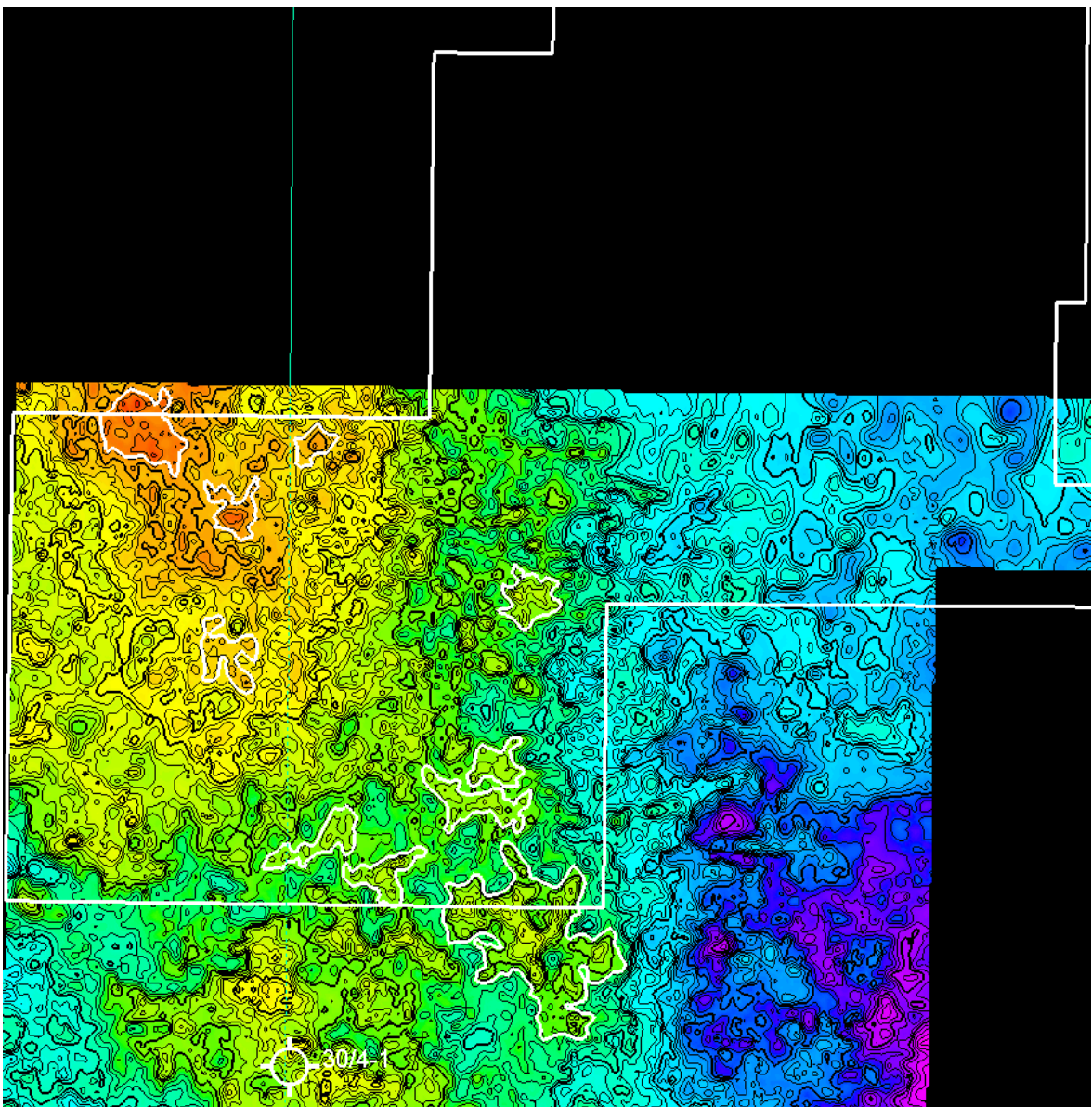


Fig. 3.5 Knabben prospect Top Lista fm/Heimdal. The map shows the Knabben structures at top Lista level (Heimdal sst) with several very irregular 4-way closures.

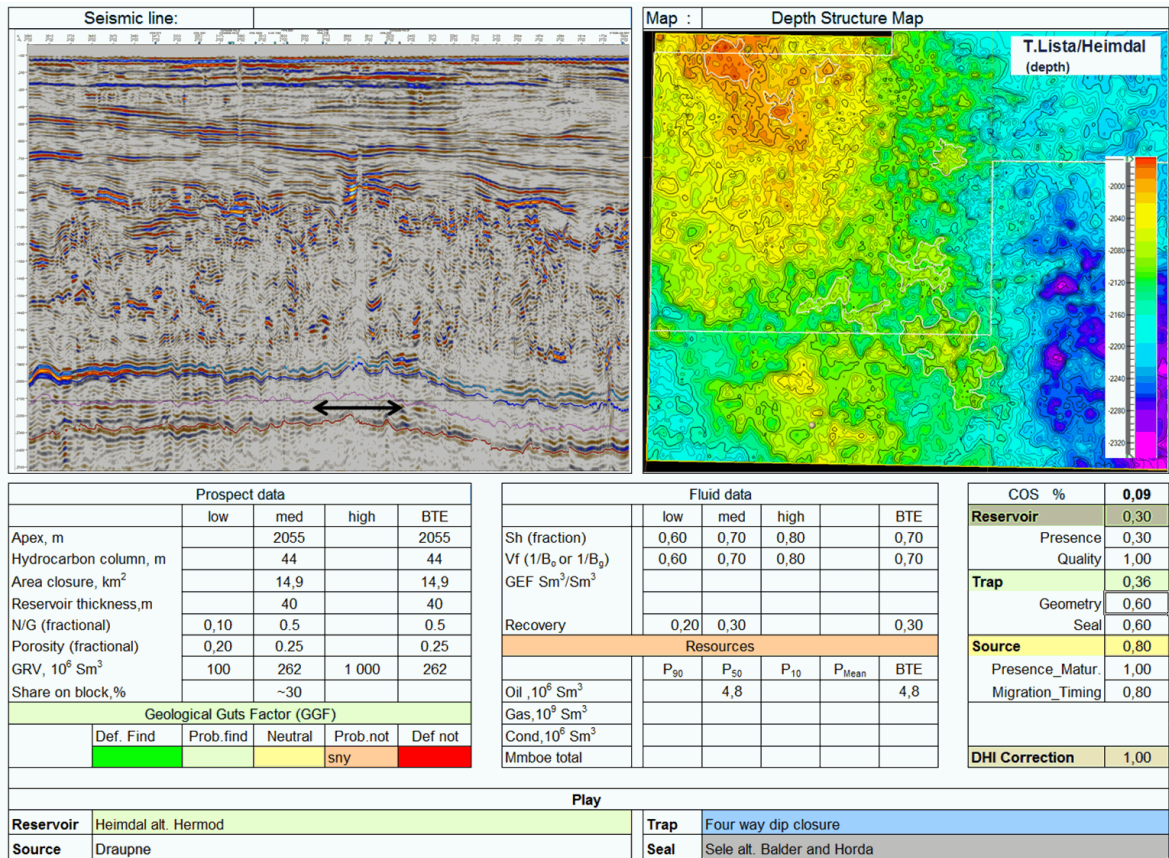


Fig. 3.6 Knabben Prospect Summary. Volume and risk for the largest of the three closures shown on the map. The risk reflects the uncertainty in both trap and reservoir presence.

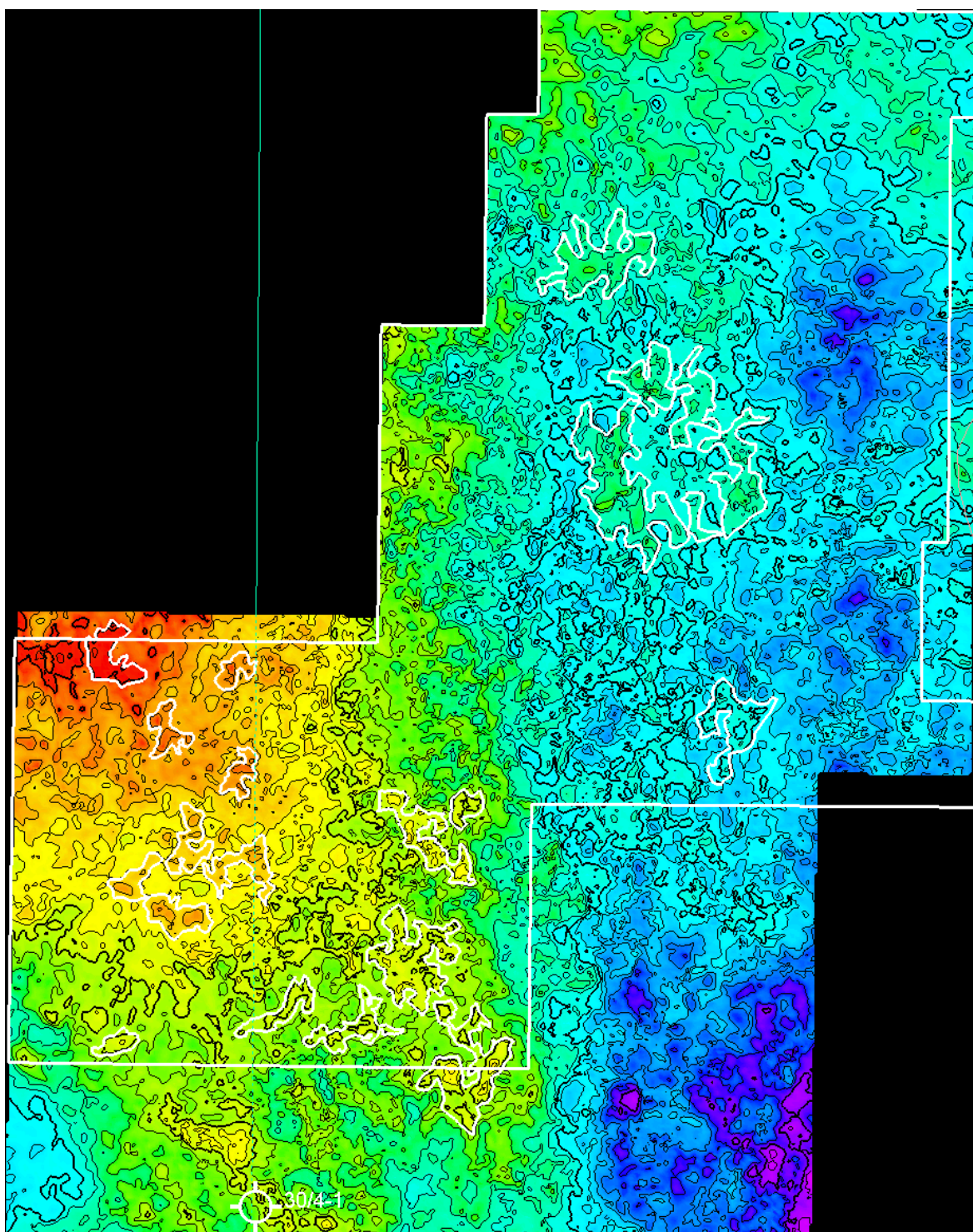


Fig. 3.7 Closures at top Balder fm.. This map illustrates that the same complexity observed at the deeper levels indicating that this is either due to sedimentary deformation within the Palaeocene package itself and / or related to rapid lateral velocity variations in the overburden.

The Knabben prospect defined on the older seismic have ~30% of its area outside the license which increases to >50% on the new data (Fig. 3.8). The prospect when defined on Top Balder is primarily a 4-way closure with very limited volume potential (Fig. 3.6), but could have a significant upside if it has a stratigraphic component (Fig. 3.9 and Fig. 3.10). The possibility for a stratigraphic controlled trap is based on the variation in the isochore (at Sele Formation) (Fig. 3.11) together with a feature that can be observed on the coloured

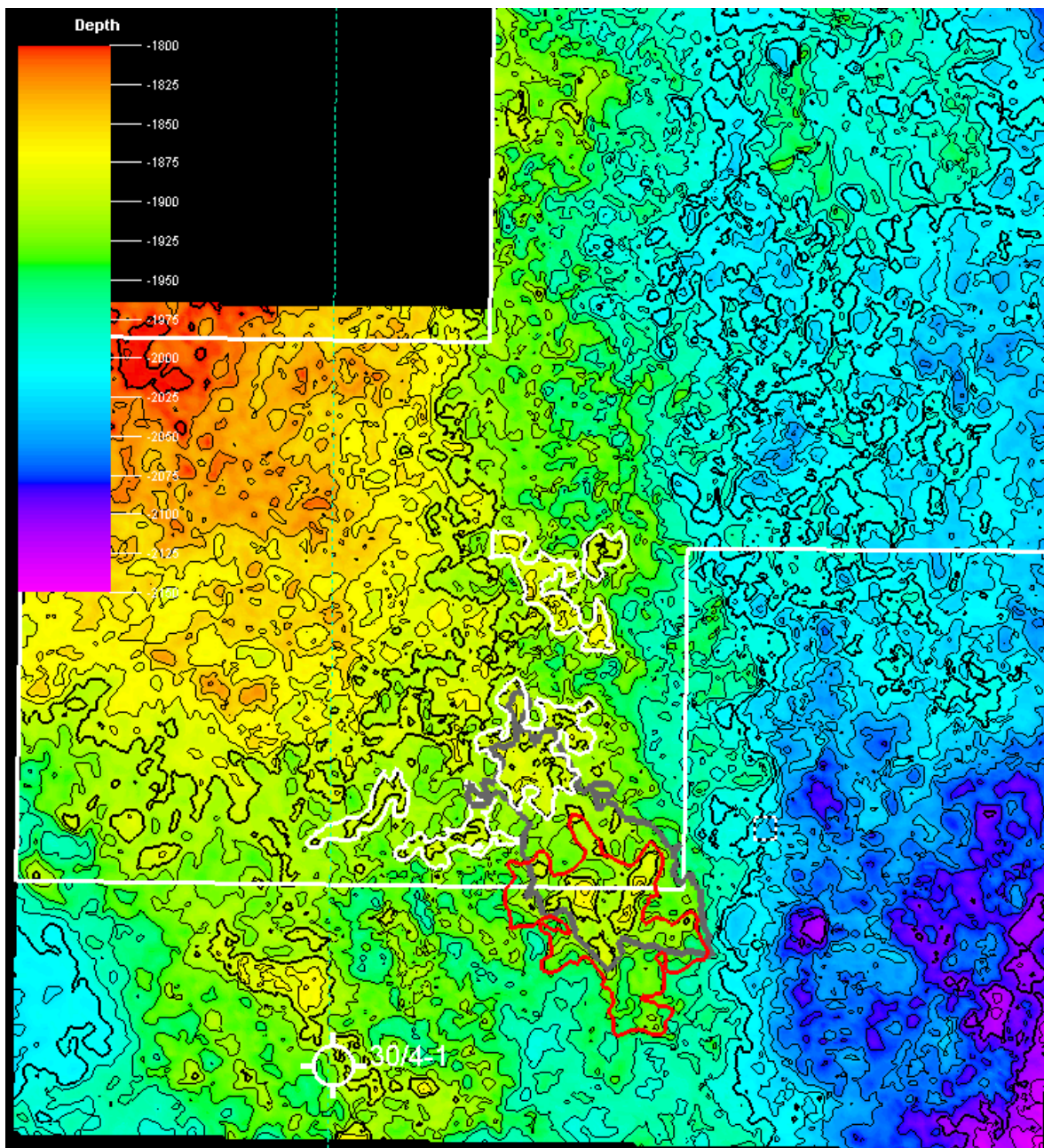


Fig. 3.8 Top Balder structural depth map. Top Balder formation structural depth map with the old Knabben prospect in grey and the new with a red outline. Other additional closures are shown with a white outline.

Seismic random line

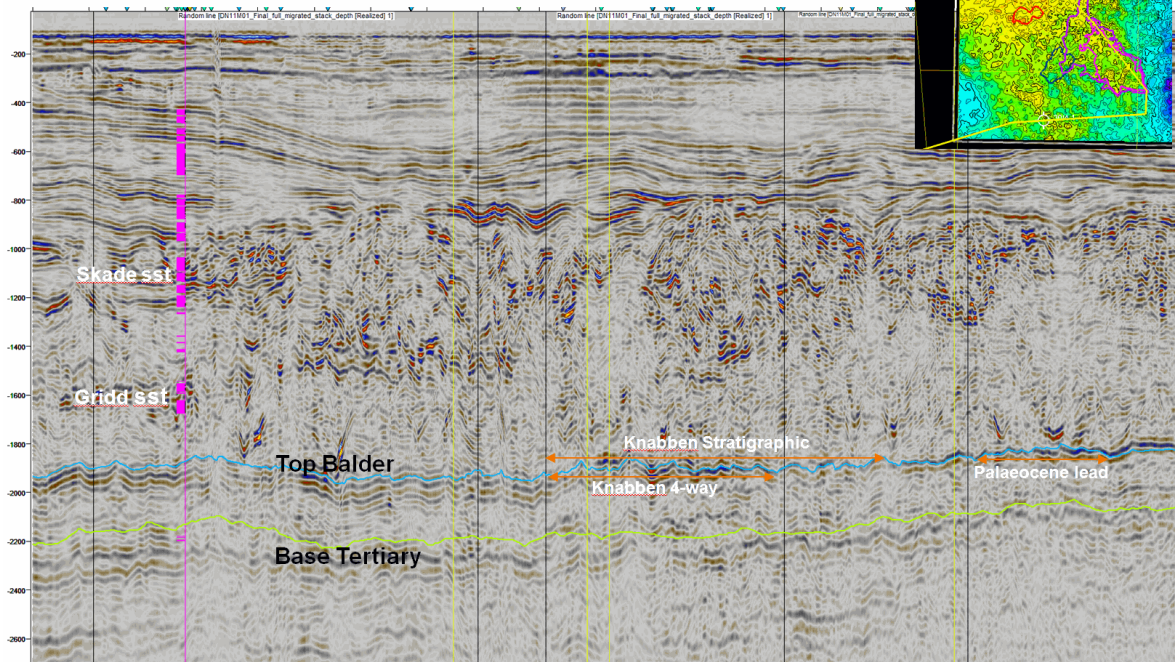


Fig. 3.9 Knabben Prospect. Seismic section through well 30/4-1 and across the Knabben prospect and further to the northwest. The line illustrate the limited seismic quality even with the latest PSDM processing. The occurrence of Skade and Gridd sands (marked on 30/4-1 well path) within the Gumbo shale as high energy events, dramatically reduces the imaging within the Palaeocene.

Knabben with stratigraphic component

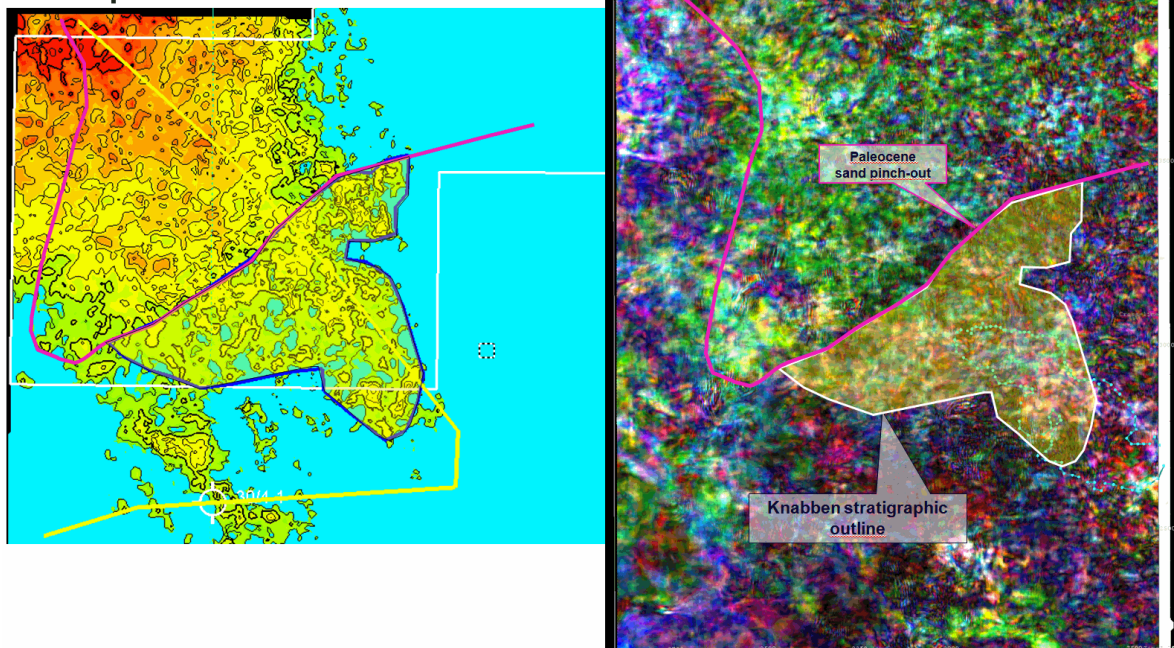


Fig. 3.10 Top Balder Formation with Knabben prospect. This figure shows the possible stratigraphic component that could exist to the Knabben prospect. The pinch-out line is derived from a thickening of the top Balder base Tertiary isochore southeast of the line which together with a feature visible in spectral decomposition domaine could indicate a wedge developed with the package (possibly within the Sele Formation)

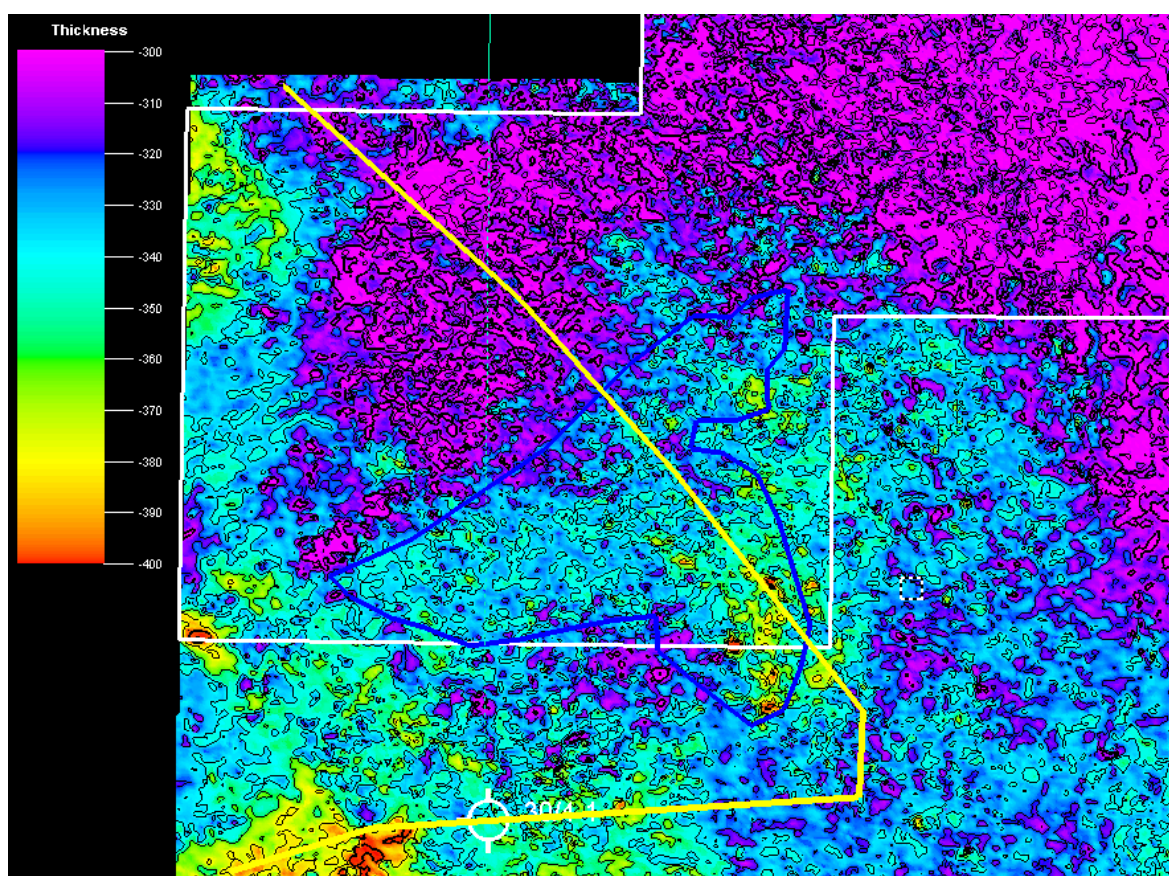


Fig. 3.11 Palaeocene isochore. *On the isochore between top Balder fm. and base Tertiary it is possible to define a pinch-out line which follows the feature observed in the spectral decomposition cube.*

inversion cube for the same interval. Detailed work done on different cubes (coloured inversion cubes and spectral decomposition cubes) have additional weak features that can be linked to possible sand fairways in a 'source to sink' manner (Fig. 3.12). The combination of sand fairways and possible pinch-out line gives the possibility for a larger stratigraphic Knabben structure. The volume potential for this stratigraphic Knabben lead is significant larger if filled to spill (Fig. 3.13), but associated with a very low probability (<<10%). The prospect is associated with two high risks; trap and reservoir, and these risks will not become less by introducing a stratigraphic component. In addition, the current seismic cannot support this model from an AVO or rock physics point of view. The data quality is too poor so this kind of information cannot be extracted with confidence, or we actually have water filled thin sandy intervals which explains the total lack of good consistent seismic anomalies within the Palaeocene package. This is reflected in a COS of 9% for this prospect which cannot justify a well and the recommendation to the license was to relinquish.

To mature this prospect further (or any other prospectivity in the license), a more sophisticated PSDM reprocessing is need or even better, acquisition of a new survey designed to solve the imaging issues related to the Gumbo shale. This was not possible within the timeframe of this license period.

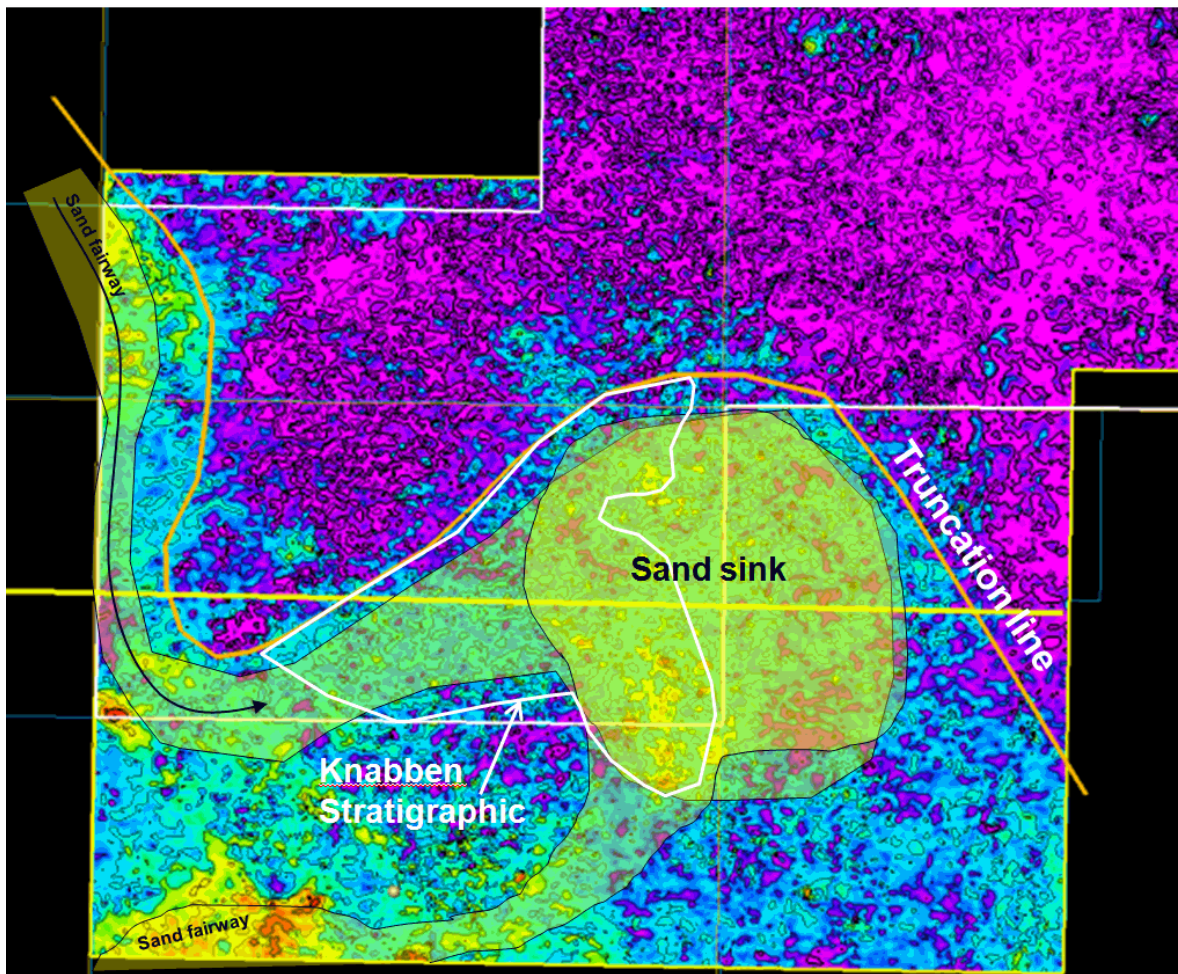
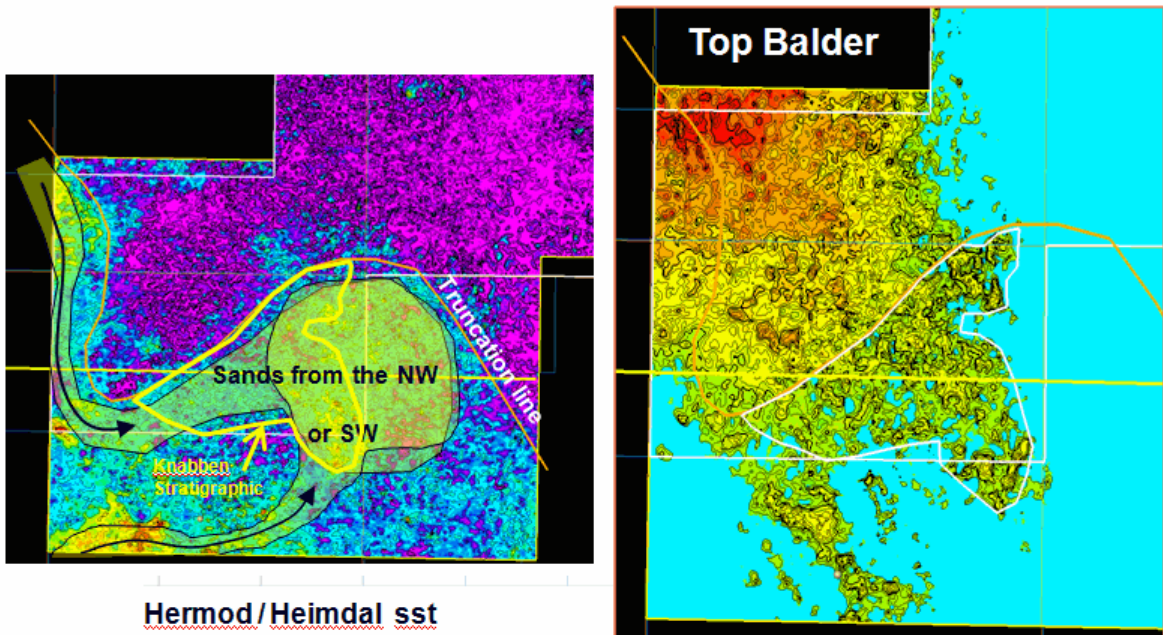


Fig. 3.12 Sand fairway model. In a local scale, the sands could be coming in from the northwest where the Ninian delta is prograding eastward through Palaeocene or more from the south as an extension of Heimdal and Hermod systems.



Hermod/Heimdal sst

Spill (m)	Area (x 10 ⁶ m ²)	GRV (x 10 ⁶ m ³)	STOOIP (mSm ³)			Rec.oil (mSm ³)		
			Min	Base	Max	Min	Base	Max
1885	5,4	37	1,0	1,6	2,4	0,2	0,4	0,9
1890	9,6	74	2,1	3,3	4,9	0,4	0,8	1,7
1895	15,5	136,8	3,8	6,0	9,0	0,8	1,5	3,1
1900	22,7	231,8	6,5	10,2	15,3	1,4	2,5	5,3
1905	31,7	367,5	10,3	16,2	24,3	2,2	4,0	8,5
1915	51	782,9	21,9	34,4	51,7	4,7	8,6	18,0
1925	64,8	1367,7	38,3	60,2	90,3	8,2	15,0	31,5

Reservoir parameters		n/g	poro	So	Bo	STOOIP fac	Rec.f.	Rec.Oil fac
Max	Case 1	0,5	0,25	0,7	0,75	0,066	0,35	0,023
Base	Case 2	0,4	0,21	0,65	0,8	0,044	0,25	0,011
Min	Case 3	0,3	0,18	0,6	0,85	0,028	0,21	0,006

Fig. 3.13 Knabben Stratigraphic lead. The volume potential for the stratigraphic Knabben lead is significant if filled to spill (~1920m).

4 ADDITIONAL PROSPECTIVITY

The additional prospectivity is linked to the presence of Grid and Skade sands as well as Utsira and Naust formation sand deposits Fig. 4.1. This report will not touch upon the Utsira and Naust formations as they are too shallow. Seismic anomalies have been observed at these levels, but these are small in size and occur as one-cycle wonders indicating very thin sands with some gas saturation.

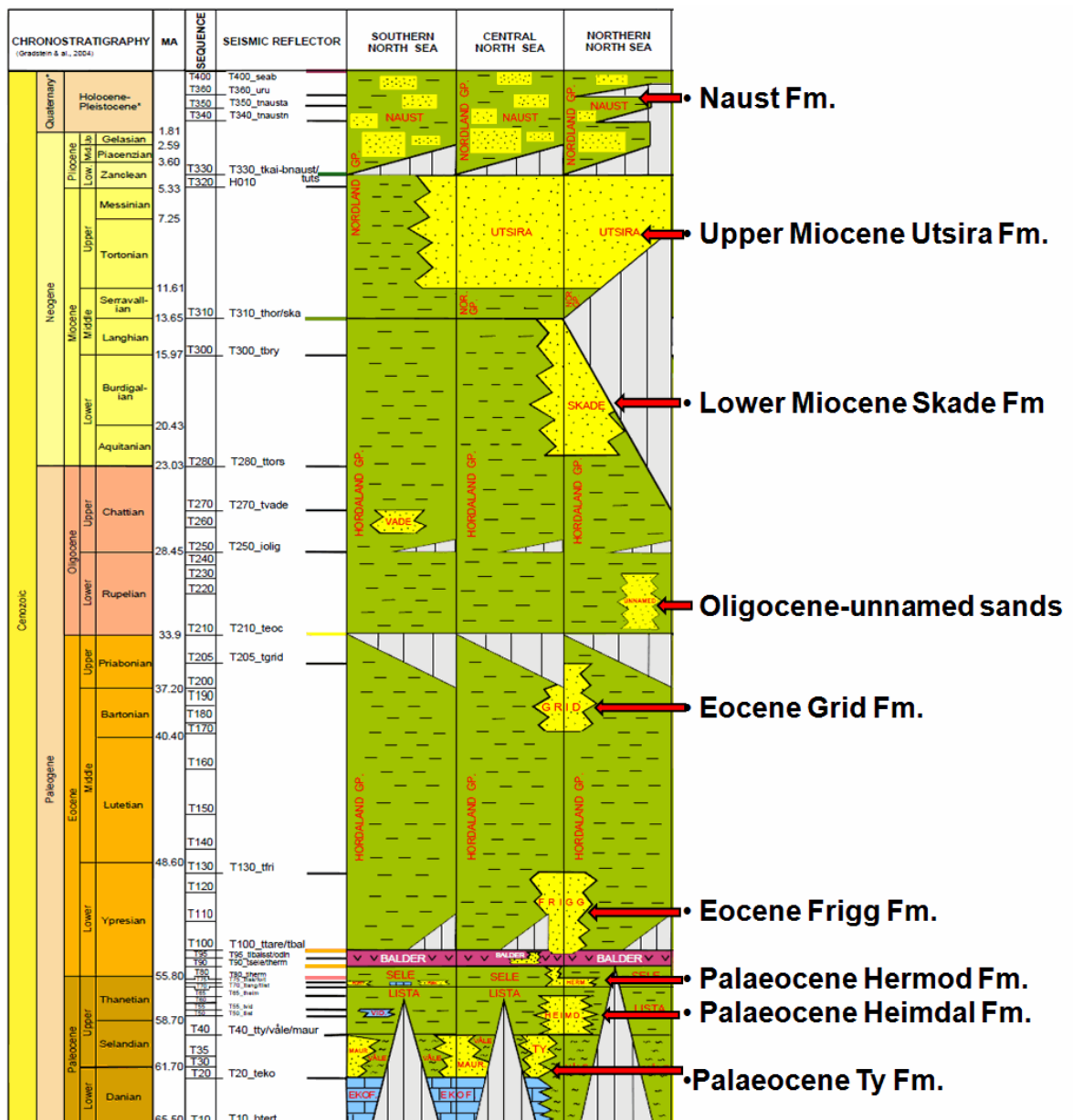


Fig. 4.1 Litostratigraphic section through the North Sea. The sands occurring in the license area is shown here. The proven plays are in the Frigg, Hermod, Heimdal and Ty sands, where as Grid, Skade, Utsira and Naust only in very special circumstances have been associated with discoveries. Frequent hc-shows have been reported in wells when intersecting these units, but very few have proven to be successful.

From the current work, the Frigg sands does not reach out into this area and is therefore not prospective (Fig. 4.2). If we look at three wells surrounding the license, there is a clear indication of more sand in the west than east, reflected in a transport direction from west towards east (Fig. 4.3).

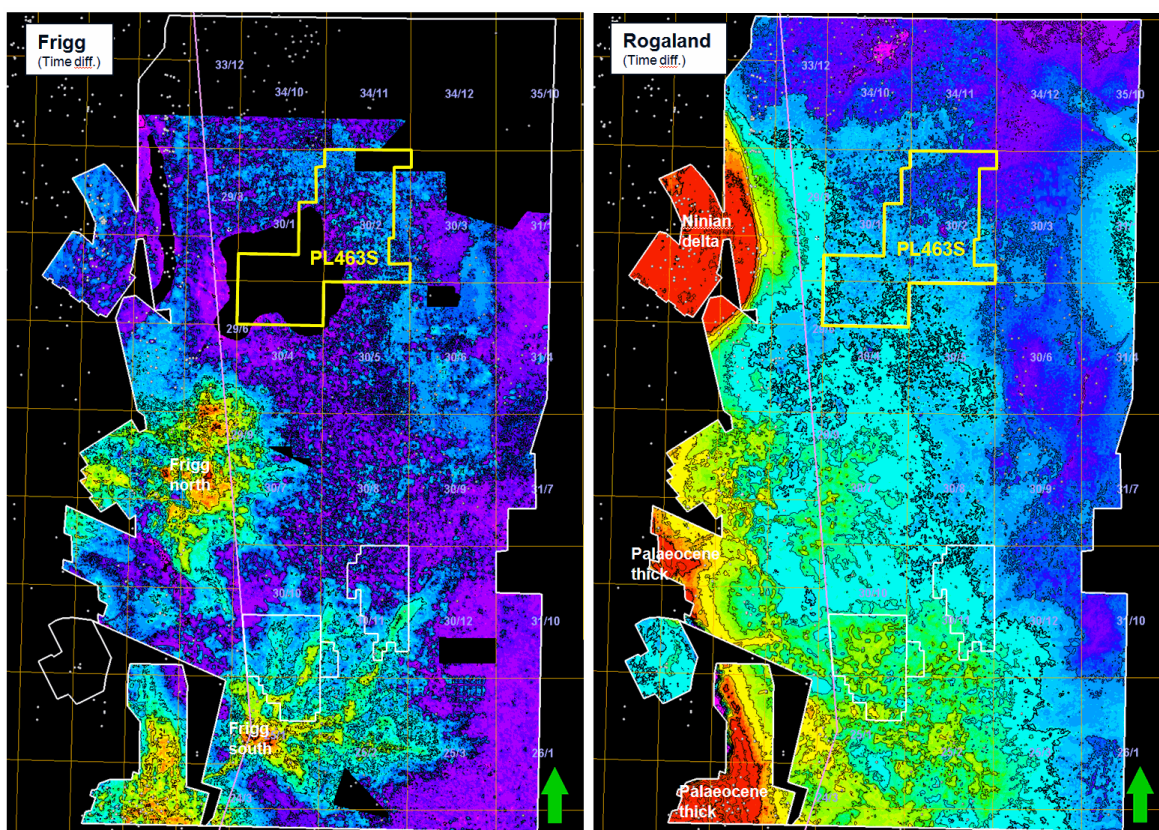


Fig. 4.2 Frigg Formation and Rogaland Group Isochores. To the left, Frigg Formation time isochore shows the two main Frigg depositional systems with few indications of reaching the license. To the right, the Rogaland Group (Palaeocene) time isochore with the southern system display a gentle wedge with decreasing thickness into the basin. Whereas west of the license, the Ninian delta has steep wedge that could indicating the presence of sedimentary processes restricting transport of sediments into the basin.

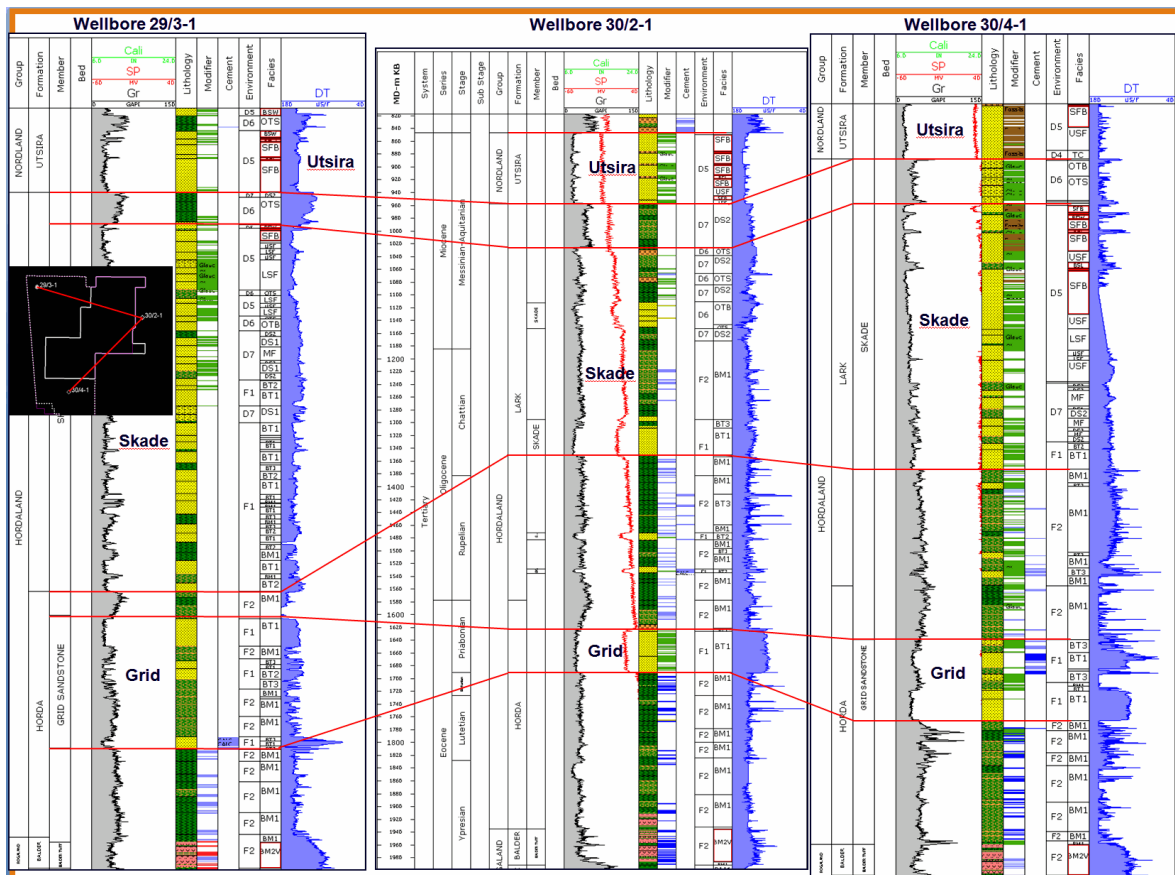


Fig. 4.3 Well correlation. This simplified correlation from 29/3-1 to the northwest to 30/2-1 at the Huldra field in the east and then to 30/4-1 just south of the license illustrate the west to east decrease in sands. This follows the general east dipping trend of these layers seen on the seismic.

4.1 Grid Formation

The Grid Formation sands occur in two main intervals in its original position in the stratigraphy. When entering into the Gumbo shale domain, the interpretation of the Grid sands gets more complicated and the sand seems to be reflected in the seismic anomalies within the Gumbo shale. Even outside the mobilized shale, the sandy Grid fm. is not a well defined seismic event that can be interpreted with a reasonable degree of confidence. The sands are present in the 30/4-1 well with a blocky lower unit and a lesser blocky unit above (Fig. 4.4). Going from the well and into the license area, the high amplitude events that most likely are linked to the sandy units in the vicinity of the well, become less continuous and even chaotic when entering into the Gumbo area (Fig. 4.5 and Fig. 2.8). This makes it very difficult to define prospects for volume estimates. Mapping of actual seismic anomalies (high amplitude events) have not resulted in any concrete feature which there could be assigned a reasonable probability for hydrocarbons. The lack of good seismic indicators reflecting the presence of hydrocarbon filled sands, makes this only an interesting play concept that we would like to pursue. To be able to do that we need a significant improvement in data quality which could not be fulfilled within the timeframe of this license period.

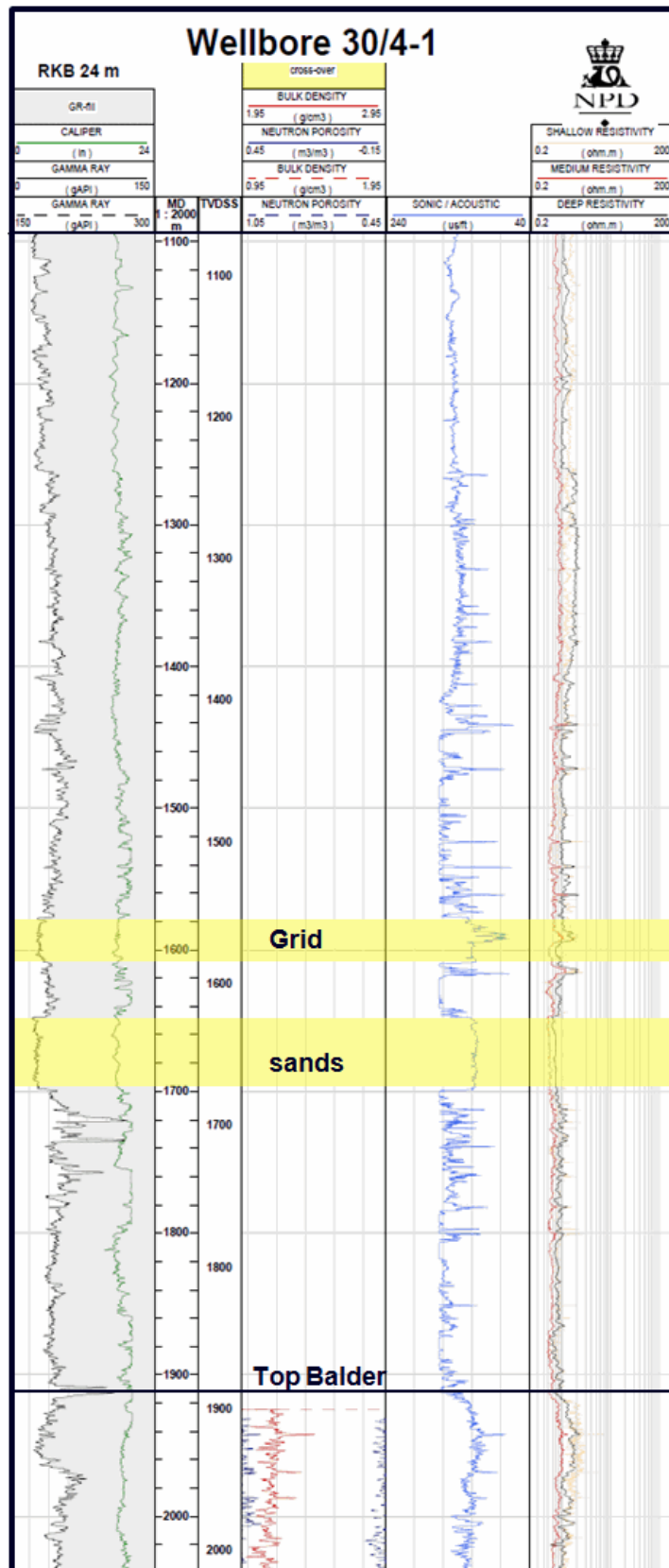


Fig. 4.4 Well 30/4-1 Grid sands. In well 30/4-1 there are two main sand assigned to the Grid Formation. The log information in this interval is limited so good CPI's cannot be generate, but general analysis indicates a very good sand with high poro-perm.

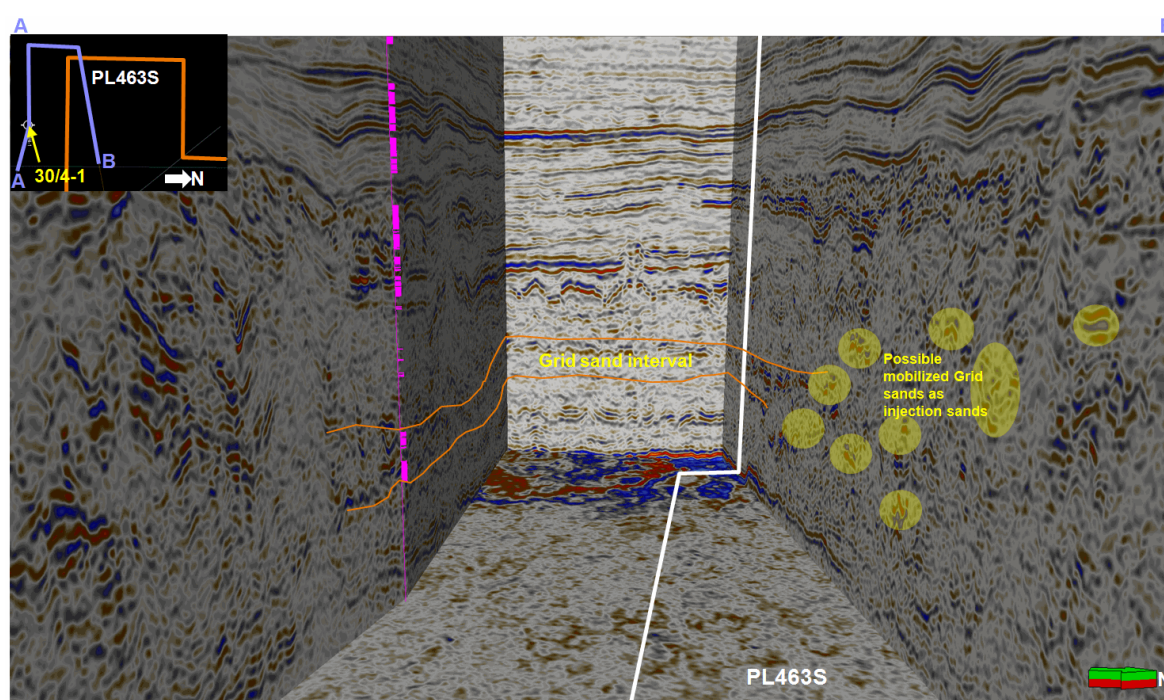


Fig. 4.5 Grid Formation seismic response. This is a randomline through the 30/4-1 well and towards the west to tie into more coherent Grid response and then into the license. Entering the license and the Gumbo shale, the response gets more incoherent and seems to be occurring with in the whole Gumbo package. Some of the sands seem to behave as injection sands.

4.2 Skade Formation

The Skade Formation sands constitute a thick package in the 30/4-1 well and seem to occur over the whole license. In general they sit on top of the Gumbo shale and seem to follow the topography as the shale is mobilized Fig. 4.6. The sequence can partly be following the top of the shale and partly being within the upper part of the Gumbo. This makes it difficult to separate between the mobilized Grid sands and the possible Skade sands within the most chaotic shale units (Fig. 4.7).

Locally, the top Skade sands form 4-way closures which have a certain volume potential. This is illustrated with Fig. 4.8 that shows a possible 4-way closure in the western part of the license close to one of the main sand fairways. These are shallow structures and biodegradation will be an issue if anything but gas is anticipated. If we envisage the combination of Grid sand layers or pods within the Gumbo shale (lower and middle part) and Skade sands within the upper part, a stacked reservoir system with both Grid and Skade sands could be possible elevating the potential of this area significantly (Fig. 4.9).

To be able to detailed map this potential new seismic is needed. The reprocessing done during the license period (with two extensions) gave us some indications of the potential in the block, but based on this limited data quality could not mature any prospect to such a state that it became drillable. The seismic complexity of the Gumbo shale and the effect it has on the ability for seismic imaging was in many ways not anticipated. To be able to unravel the potential of this interval as well as in the Palaeocene, new special seismic designed to solve the spatial problems associated with the Gumbo shale has to be acquired. This was not possible within this time period and the license decided to relinquish it.

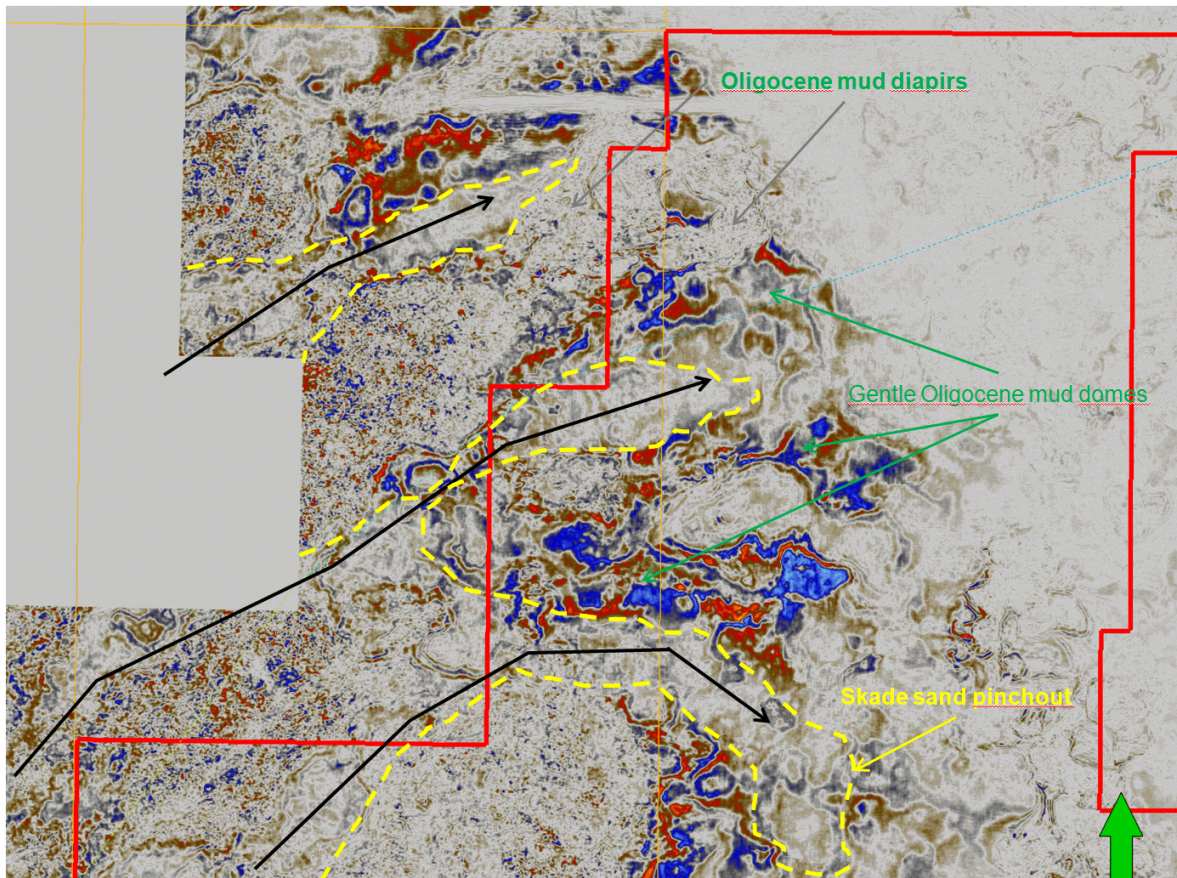


Fig. 4.6 Shallow timeslice through Skade Formation. This timeslice through the Skade and Gumbo system display the interaction between northeast prograding Skade sand fairways and the mobilised and mounding Gumbo shales.

Seismic random line

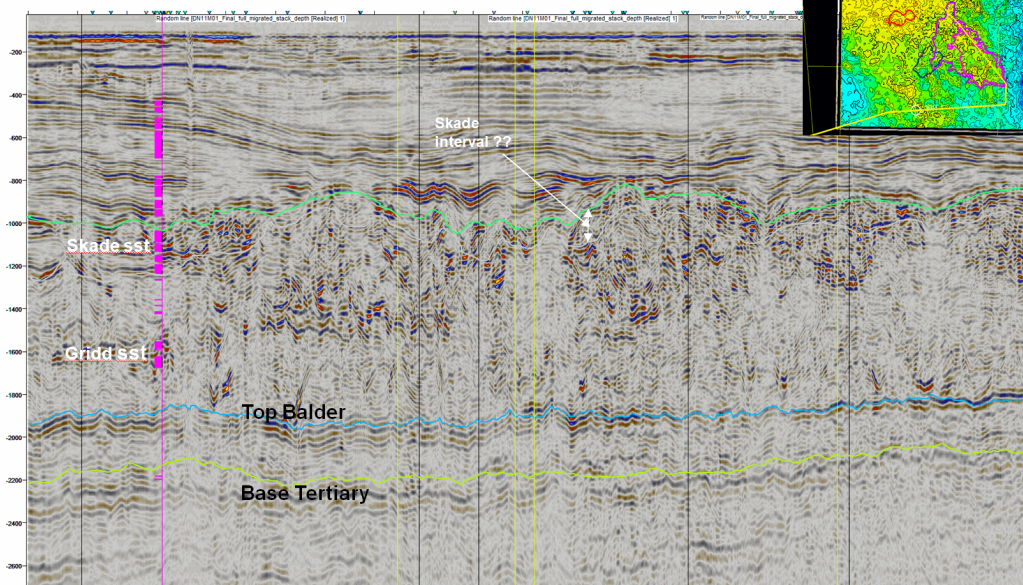


Fig. 4.7 Seismic section with possible Skade Formation sands. This sections shows the possible location of the Skade sands and how it interacts with the Gumbo shale. The topographic relief of the interpreted top Shade sands have generated possible 4-way closures that could be prospective.

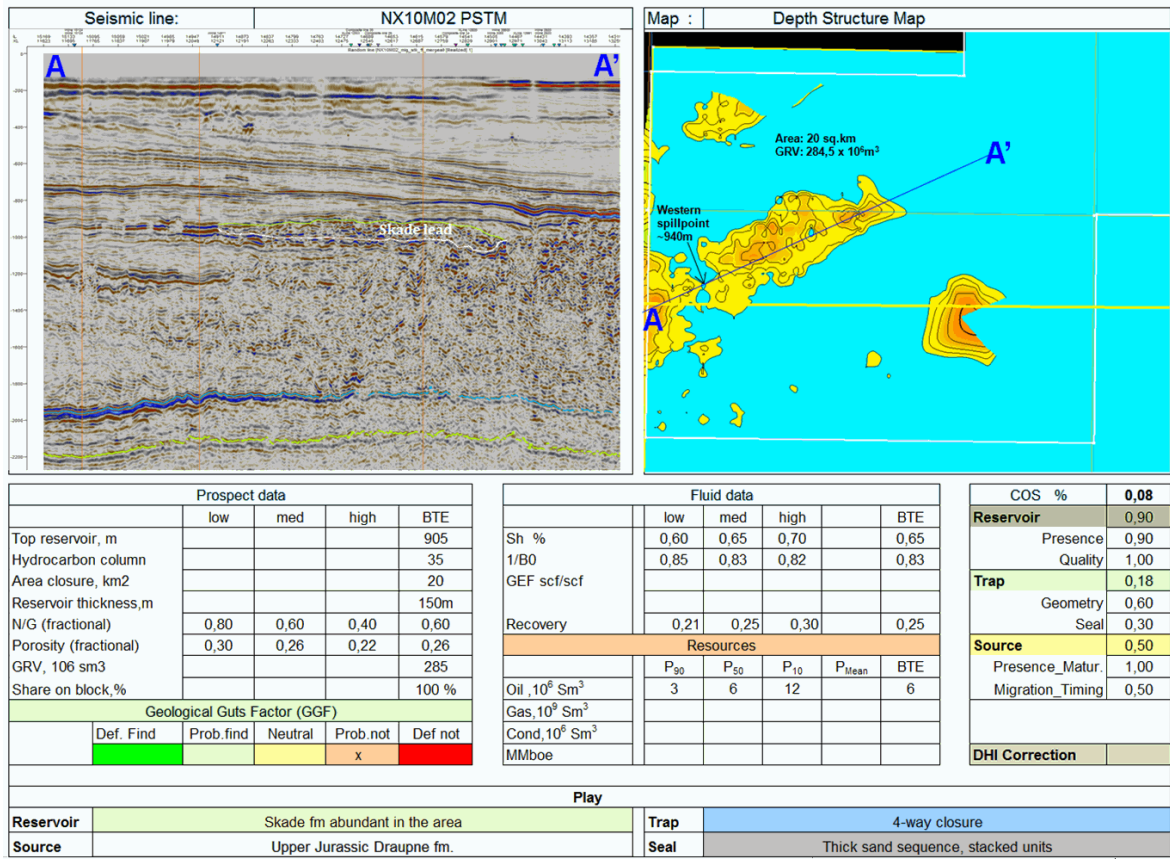


Fig. 4.8 Skade lead prospect sheet. This illustrates the potential that could be present in the Skade Formation. Several similar features can be interpreted with various confidence. Main risk will be trap (seal) and filling, i.e. how to migrate hydrocarbons into these sands.

Seismic random line

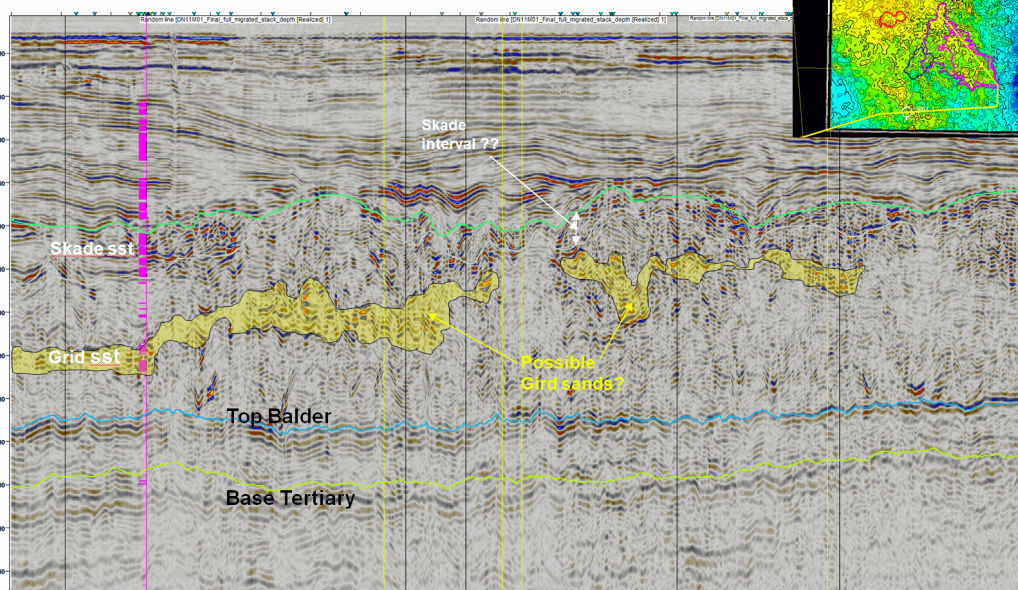


Fig. 4.9 Seismic section with both Skade and Grid Formation sandstones. The potential of the Grid and Skade sands within the Gumbo shale is shown in this section. The high amplitude events within the shale could represent injected and or displaced Grid sands with a Skade sand 'blanket' on top of the Gumbo shale. The Grid sands could behave as conduits for hydrocarbons into the Skade sands or as separate reservoirs.