Relinquishment report PL414 and PL414B

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Relinquishment report PL414 and PL414B

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1 INTRODUCTION

1.1 Licence owners

The owners of the PL414 and PL414B are:

- **Det norske oljeselskap ASA 40% (operator)**
- Noreco 20%
- Faroe 20%
- Bayerngas 20%

Voting Rules : 3 companies and minimum 50%

1.2 Award and work program

The PL 414 license was awarded 16.02.2007 as an APA 2006 license, valid to 16.02.2014. The whole area awarded is seen seen i map Fig. 1.1. The shaded areas are areal relinquished in 2013. The remaining license PL414 and PL414B is seen in pink.

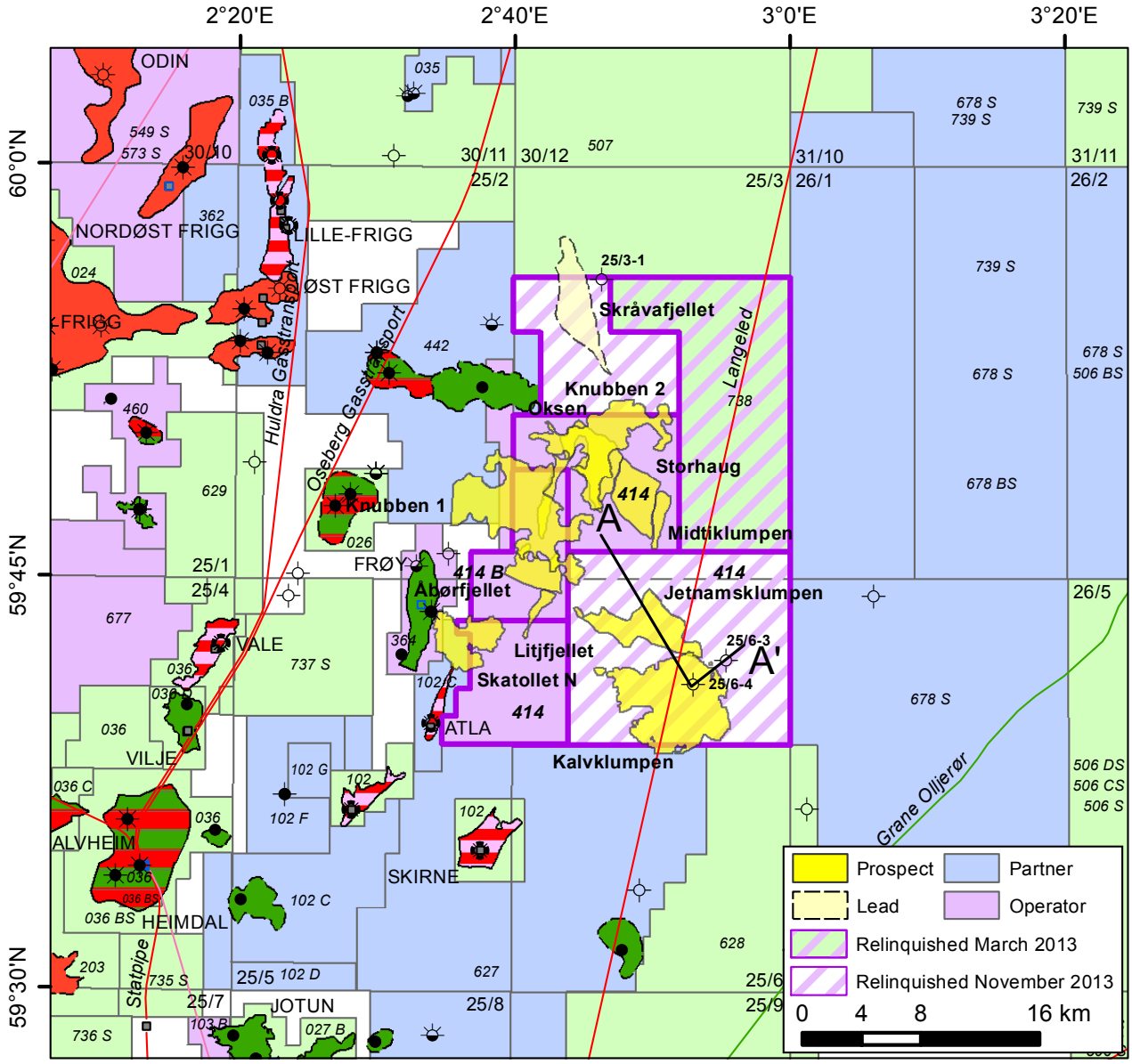

Fig. 1.1 License outline and prospects

The work program for this award included:

- Reprocess 3D seismic within 2 years, fullfilled
- DoD within 3 years, included 1 year extension granted March 2013
- BOV within 4 years (after extensions:16.02.2013)
- PUD within 5 years (after extensions: 16.02.2013)

The Kalvklumpen prospect, seen in Fig. 1.2, was drilled as 25/6-4S in 2012 by Songa Delta. The well was plugged and abandoned as a dry well 15.02.2012.

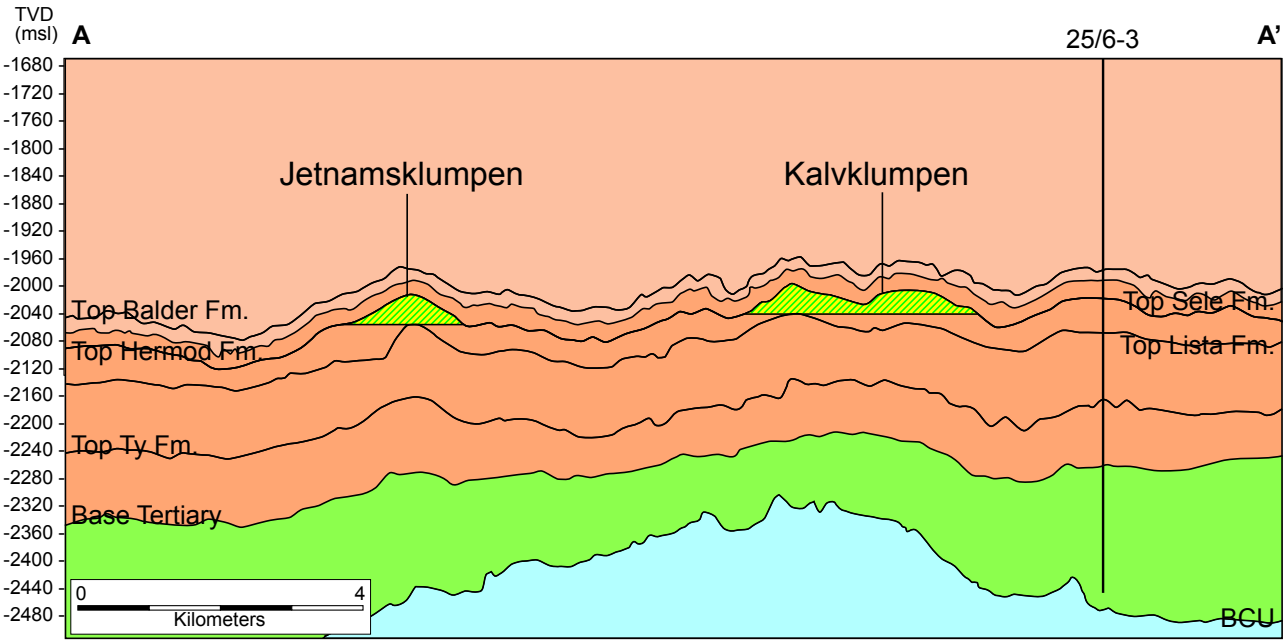

Fig. 1.2 Geoseismic section of the Kalvklumpen and Jetnamsklumpen prospects

1.3 PL 414/PL 414B pre-drill prospectivity

The Kalvklumpen prospect is located in the southeastern part of PL 414 and the prospect consists of two targerts, a primary target in the Paleocene Hermod Formation and a secondary target in the Jurassic Brent/Vestland Group, see Fig. 1.3 for the prospect location.

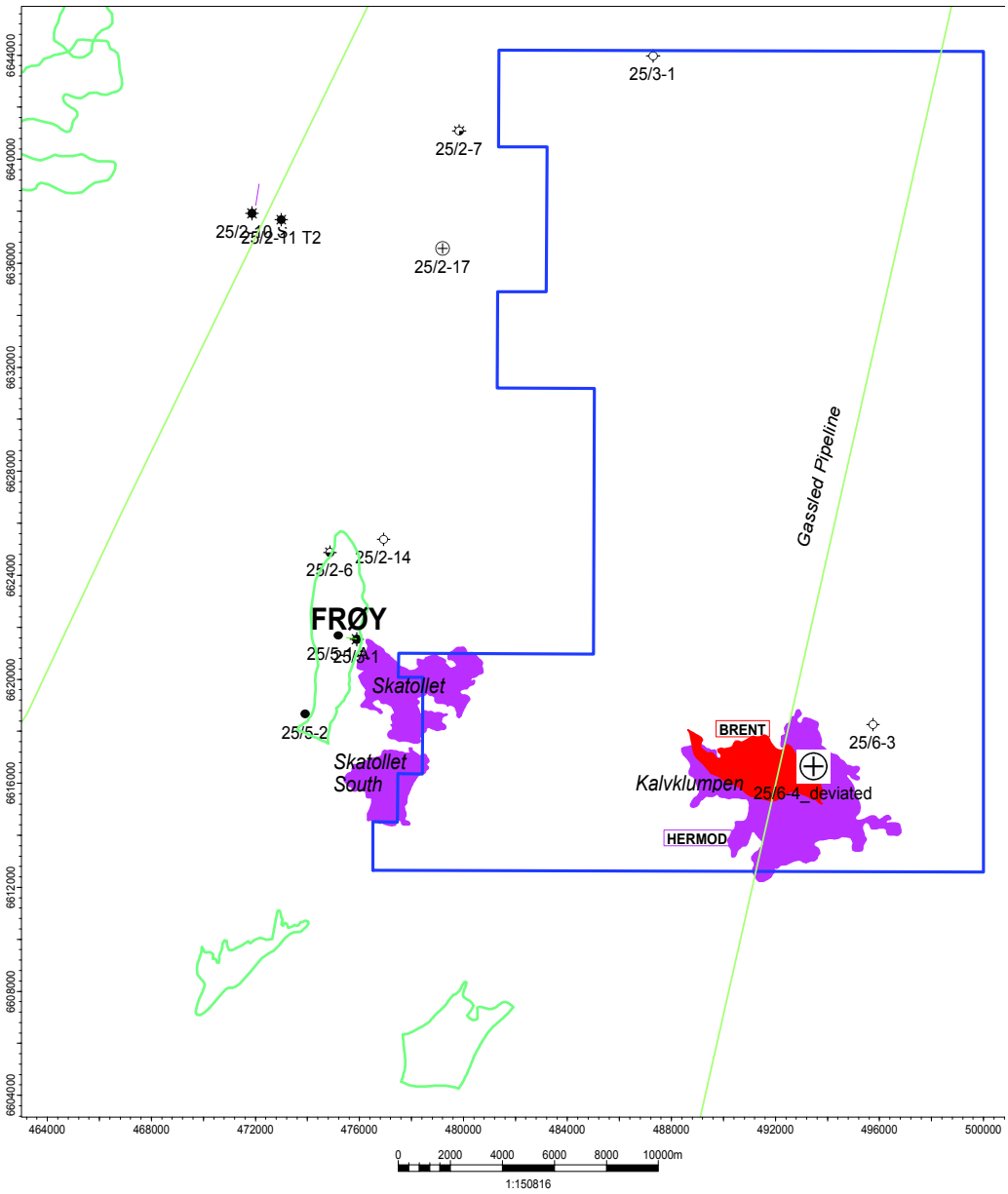

Fig. 1.3 The original outline of PL414 awarded in APA 2006

Reference well for the Paleocene target is the 25/6-3 well, which is located approximately 3 km to the northeast of the spud location. Reference wells for the Jurassic target is the 26/4-1 well, which is located approximately 13 km to the northeast of the spud location, and the 25/6-2 well which is located approximately 14 km to the south.

The primary Paleocene target is a 4-way structural closure Fig. 1.4, whereas the secondary Brent target is a fault bounded 3-way structural closure, Fig. 1.5.

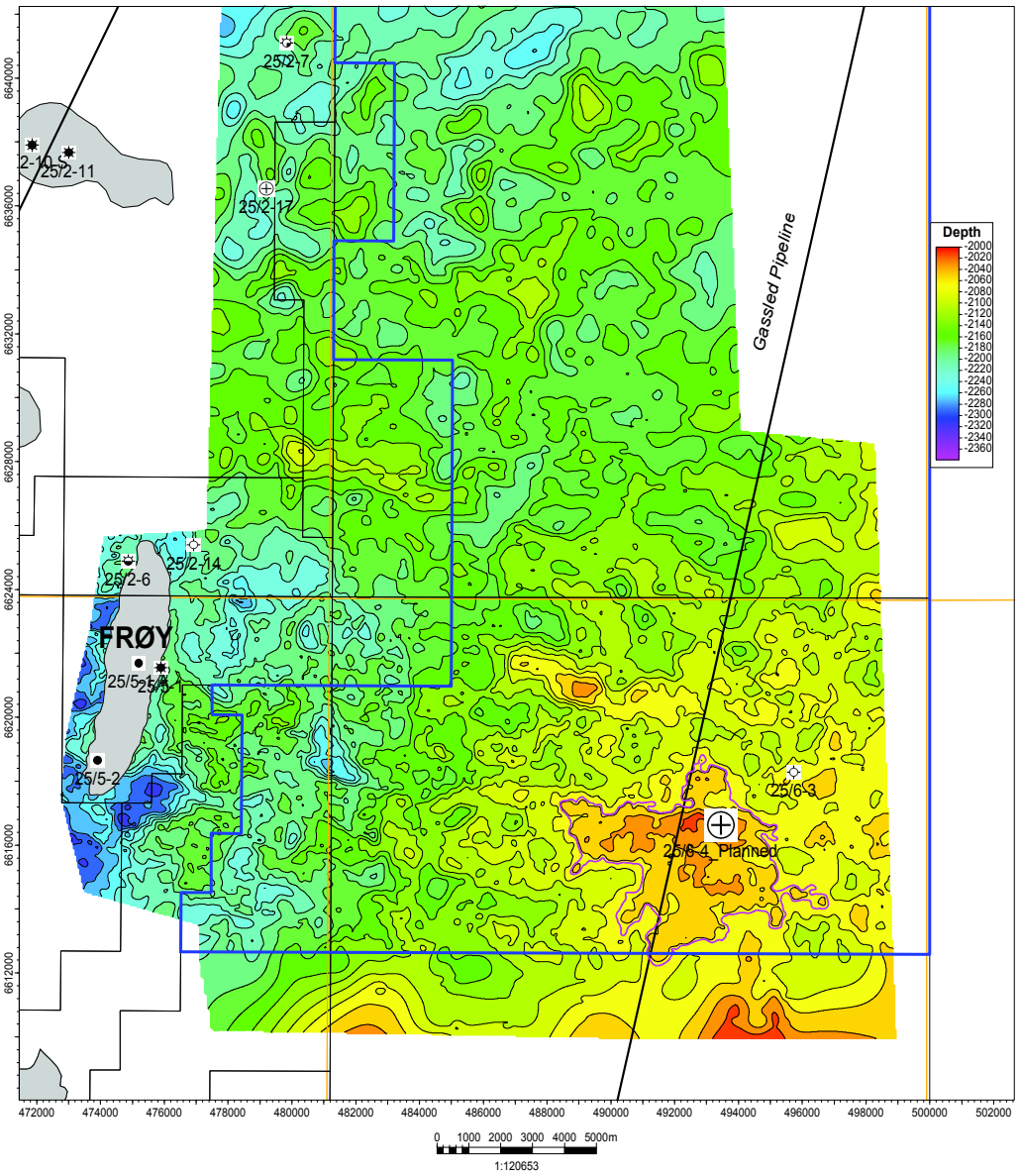

Fig. 1.4 Kalvklumpen Hermod outline. *Top Hermod depth map*

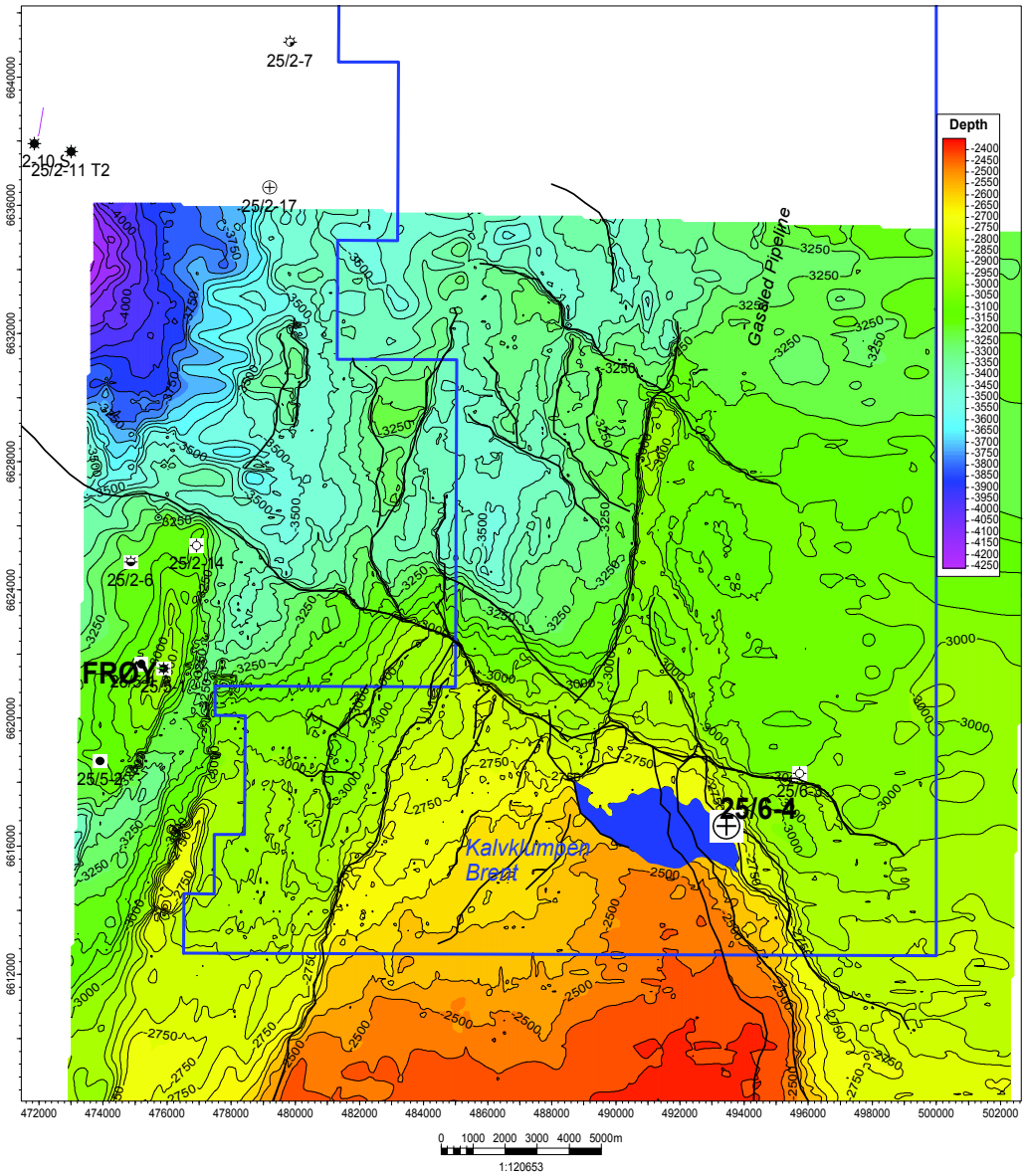

Fig. 1.5 Kalvklumpen Brent outline. *Top Brent depth map*

Fig. 1.6 is a schematic cross section which illustrates the prospect concept for both targets.

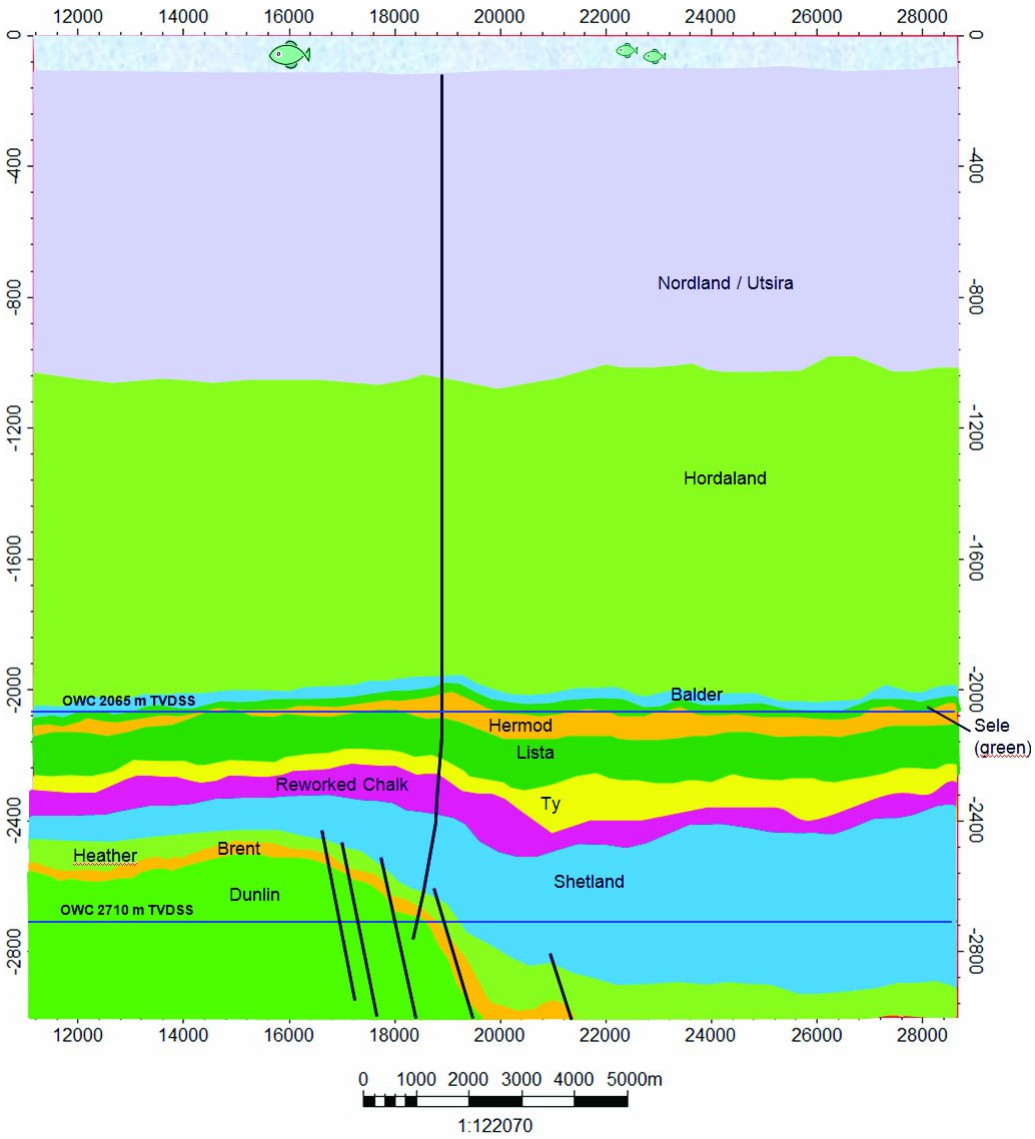

Fig. 1.6 Schematic prospect cross section. *Paleocene Hermod and Brent target locations*

The source rock for both target levels is the Heather and Drapne shales which are proven to be mature in the basin to the northwest, approximately 25 km from the target location. Hydrocarbon migration into the prospect is considered to be the main risk for the prospect.

Well objectives:

- To carry out all operations in a safe and cost efficient manner without:
  - Causing any injury or ill health to any personnel involved;
  - Creating any damage to the environment
- To investigate the hydrocarbon potential in the primary and secondary targets
- Fulfil NPD's regulations for data acquisition
- In case of discovery:
  - Core the reservoir section(s)
  - Perform logging with an extensive wireline logging suite

The planned TD criteria for the dry case scenarion was 50 m into the Dunlin Group, prognosed to be 2939 mMD.

A table showing the expected recoverable reserves for the Kalvklumpen Prospect prior to drilling the 25/6-4S well, is presented below, in **Table 1.1**

Table 1.1 Expected recoverable reserves

PL 414 and 414B					**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										
Kalvklumpen primary target	Hermod fm	Oil	0.5	0.17	11	1	18	2	26	3
Kalvklumpen secondary target	Brent Gp	Oil	0.5	0.16	4	0.5	9	1.3	16	2.5

2 DATABASE

2.1 Seismic database

The seismic database is shown in Fig. 2.1 and in Table 2.1

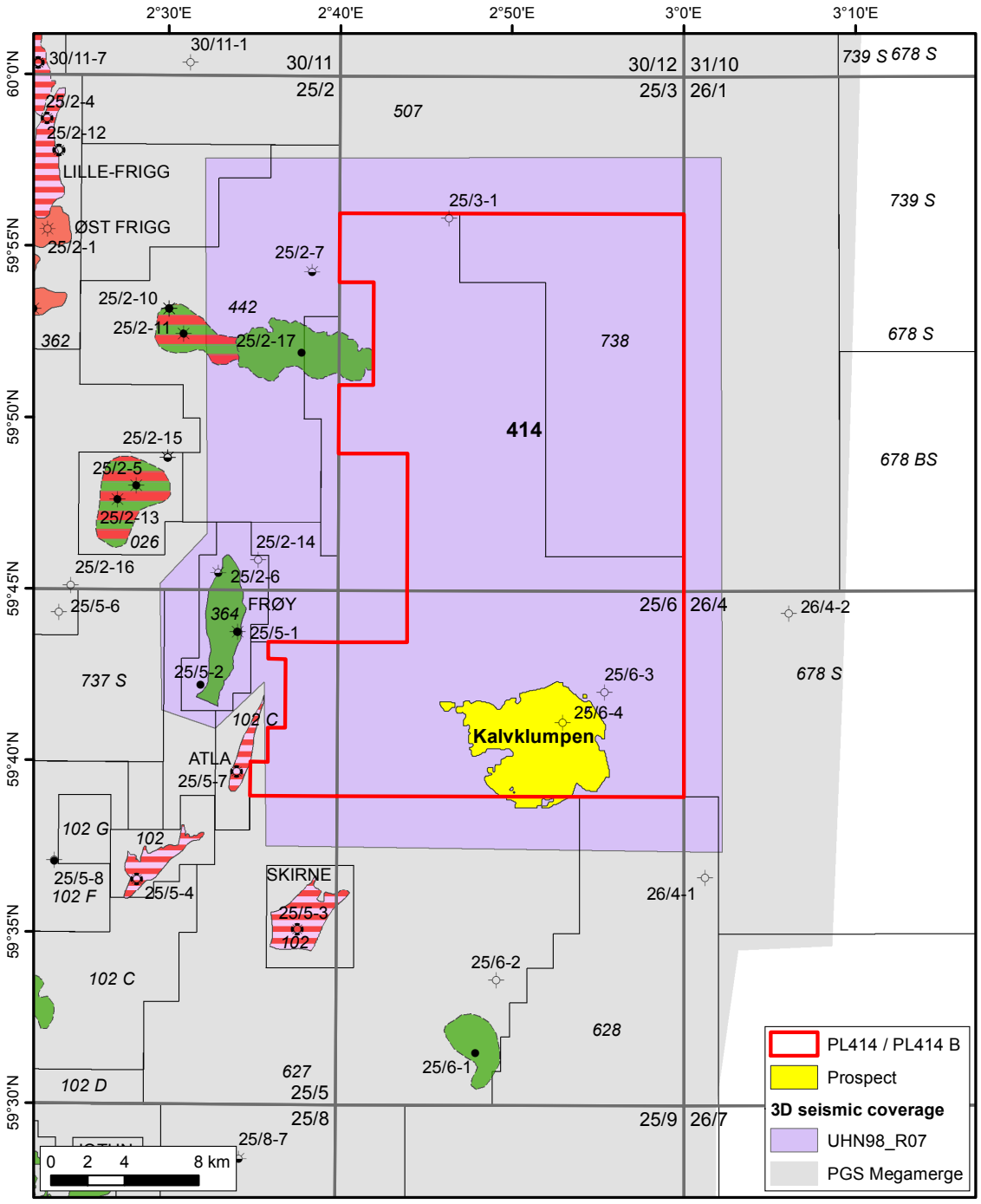

Fig. 2.1 Seismic database. *Seismic 3D surveys used in the mapping of Kalvklumpen.*

Table 2.1 Seismic 3D surveys

Seismic Surveys	3D/2D	Angle stacks	Comments
UHN98	3D	Yes	Base survey used for re-processing
UHN98_R07	3D	Yes	Used for generation of seismic attribute cubes
MC3D-CNS-MEGA-SVG-I08, J08	3D	No	Used for regional well-ties

The angle stacks include near, mid and far offsets for the UHN98 and UHN98_R07 3D data.
In addition, the following attribute cubes were generated from the UHN98_R07 data;

- absolute acoustic impedance
- absolute lambda-mu
- absolute lambda-rho
- absolute poissons ratio
- absolute shear impedance
- abolute vpvs ratio
- relative acoustic impedance
- relative poissons ratio
- relative vpvs ratio

2.2 Well data

Fig. 2.2 shows all the wells used in the work done for PL 414/PL 414B. All key wells are marked in red. The original well database from the aplication 2006 is shown in Table 2.2 and from the aplication 2009 in Table 2.3.

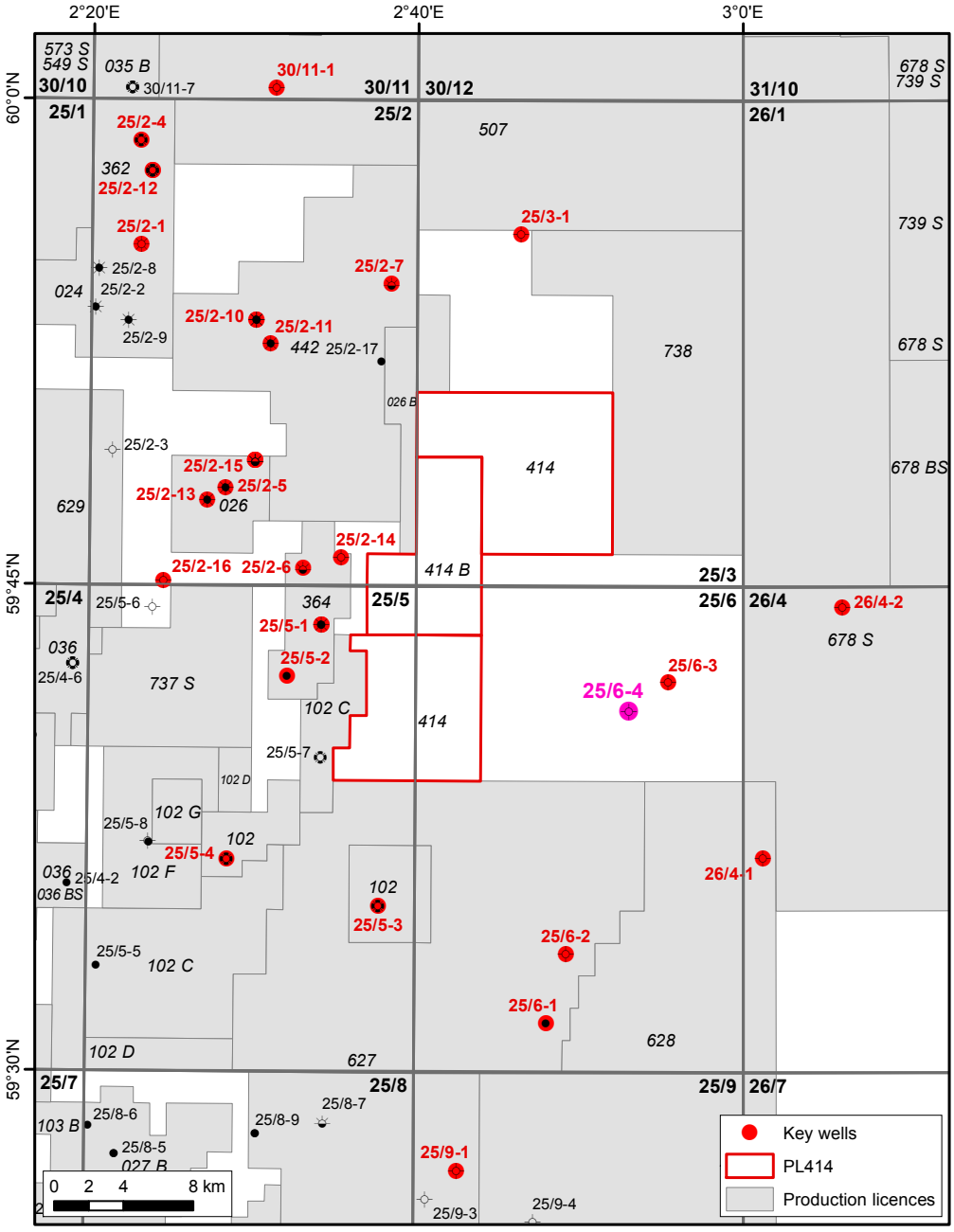

Fig. 2.2 Map of common well database

Table 2.2 Original well database

Well	Field/disc. Name	Comp. Year	TD depth m MD	TD formation
25/2-1	Øst Frigg	1973	2740	Hardråde
25/2-10 s	Gamma	1986	2967	Ekofisk
25/2-11	Gamma	1987	2075	Frigg
25/2-12	Lille Frigg	1988	4102	Statfjord
25/2-13	Lille Frøy	1990	3909	Triassic
25/2-14		1991	3623	Statfjord
25/2-15 R2		1993	3942	Dunlin
25/2-16		2001	3792	Dunlin Grp
25/2-4	Lille Frigg	1975	4360	Smith Bank
25/2-5	Lille Frøy	1976	4002	Triassic
25/2-6	Frøy	1977	3750	Smith Bank
25/2-7		1982	4110	Dunlin Grp
25/3-1		1989	3922	Statfjord
25/5-1	Frøy	1987	3429	Hegre Grp
25/5-2		1989	3304	Drake
25/6-1	no name	1986	2881	Basement
25/6-2		1992	2392	Drake
25/6-3		1999	2475	Hardråde
26/4-1		1987	3690	Hegre Grp

Table 2.3 Well database APA 2009

Well	Biostrat	Synthetic	Petrophysics	Key well
25/2-6	Yes	No	Yes	No
25/2-7	Yes	Yes	Yes	Yes
25/2-13	Yes	No	No	Yes
25/2-14	Yes	Yes	Yes	Yes
25/2-15 R2	25/2-15	No	No	Yes
25/2-17	No	Yes	Yes	Yes
25/5-1 A	Yes	No	No	No
25/5-2	Yes	No	Yes	No
25/5-3	Yes	No	No	No
25/5-4	Yes	No	No	No
25/5-7	No	No	No	No
25/6-1	Yes	No	No	No
25/6-2	Yes	No	No	No
25/6-3	Yes	Yes	Yes	Yes

2.3 Special studies

Several special studies have been carried out, both in-house and by external parties, to address the geological uncertainties of the PL 414 prospectivity. These studies includes:

Fluid Inclusion Study
A stratigraphic reconstruction of bulk volatile chemistry from fluid inclusion (FIS study) was done on the wells listed below, by the Fluid Inclusion Technologies, Inc.
25/2-6
25/2-7
25/3-1
25/5-2
25/6-3
25/6-3
The study was done to give implications for migration into the Hermod (Paleocene) section of PL 414. In general there was limited evidence for focused migration of oil or gas into the Tertiary, with one important exception:
25/6-3 displays dry to wet gas indications, proximity to gas, and rare, low gravity oil inclusions in the Hermod Formation. Data suggest reservoir of somewhat biodegraded (or mixed thermogenic / biogenic) gas in the vicinity.

AVO Modelling
The results of the AVO analysis are:

- Gas case is unlikely as a pronounced AVO effect should be observed based on AVO modeling. This is not seen in the data
- Separating between oil and brine case is difficult due to the low variations in AVO effects shown in the modeling, possibly caused by tuning and surrounding layers
- Thin shale between the Hermod sands in 25/6-3 and sand/shale layer on top of Hermod upper sand can contribute to the signal, as the wedge model (includes these layers) and AVO modeling (simplified model without these layers) give different results
    - AVO: Top of sand is a weak positive in oil case
    - Wedge: Top of sand is weak negative
- Base Hermod is expected to be a soft event with amplitude dimming in an oil case. This is partly observed in the parts of Kalvklumpen where thick Hermod sand (> 30 m) is expected

Core description
An in-house core description of the Hermod and Sele formations resulted in a broader understanding of injected sandstones. Core description of 25/6-3 clearly indicate structural features of 3 m thick injected sand unit in the shale above the main Hermod Formation.

3 KALVKLUMPEN EXPLORATION WELL 25/6-4S

3.1 Kalvklumpen pre-drill prospect evaluation

The Kalvklumpen prospect is situated on the southern tip of the Bjørgvin Arch, between the Stord Basin and the Heimdal Terrace in the North Sea, southeast of the Frøy field.
The Kalvklumpen primary target is a 4-way cosure of Late Paleocene Hermod Formation reservoir, outline is shown in the top Hermod map, **Fig. 3.1**. The reservoir is sealed by Sele Formation shales, see sesmic section **Fig. 3.2**

The secondary target is a 3-way closure of Mid Jurassic Brent/Vestland Group reservoir against a fault , seen in the top Brent map. Fig. 3.3. There is a lateral fault seal and the Late Jurassic shales seal vertically.

The reservoir quality for both prospects was defined by the nearby wells. For the Jurassic target the reservoir quality of the 26/4-1 and the 25/6-2well are used, located approximately 13 km to the northeast and 14 km to the south of the spud location. The reservoir reference well for the Paleocene target is the 25/6-3 well, which is located approximately 3 km to the northeast of the spud location. The main source rock for oil and gas for both prospects are the Heather and Draupne shales, and the hydrocarbones are expected to migrate from the west into the prospects.

The well and the two targets are seen in the cross section Fig. 3.4.

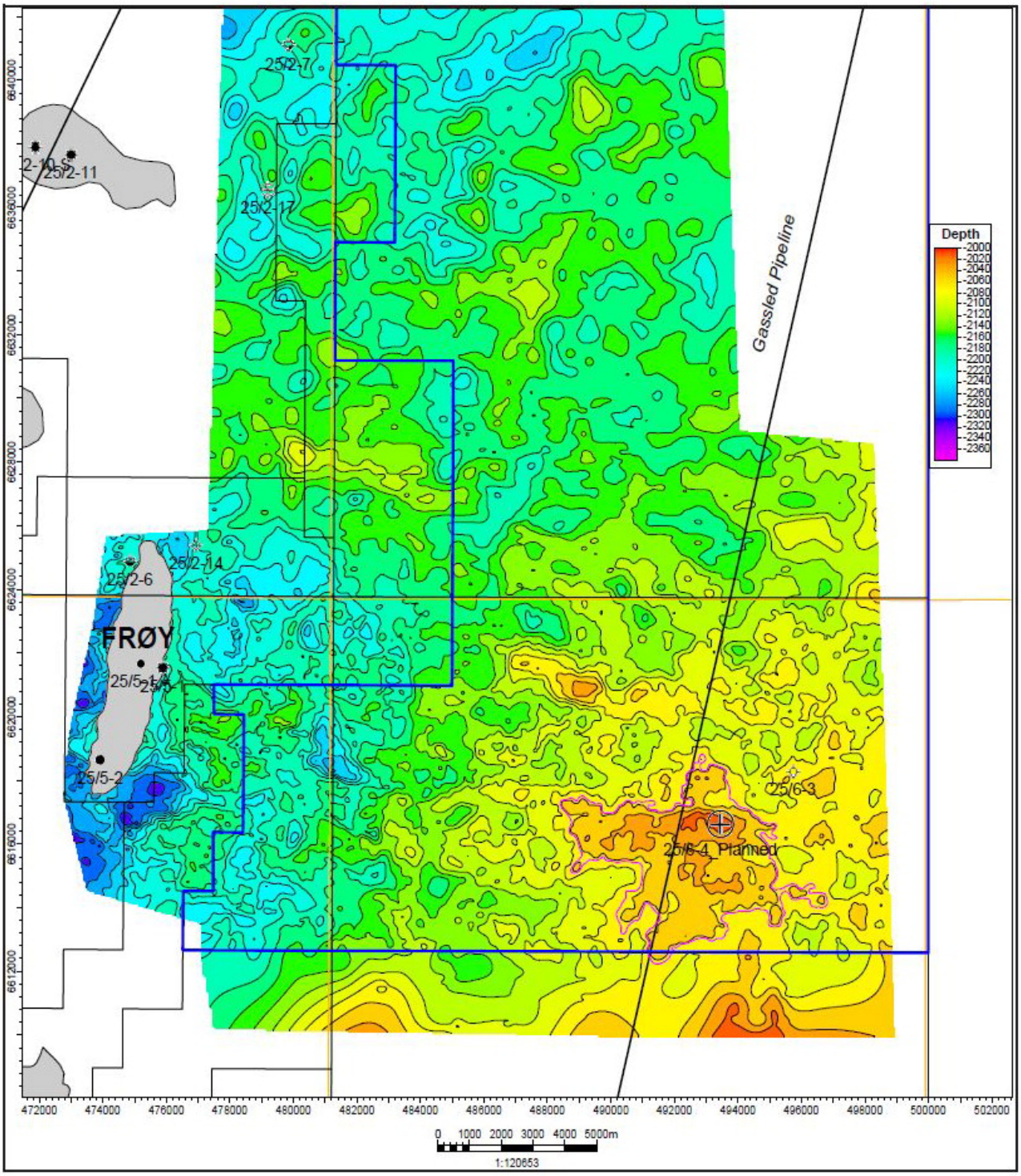

Fig. 3.1 Top Hermod depth map

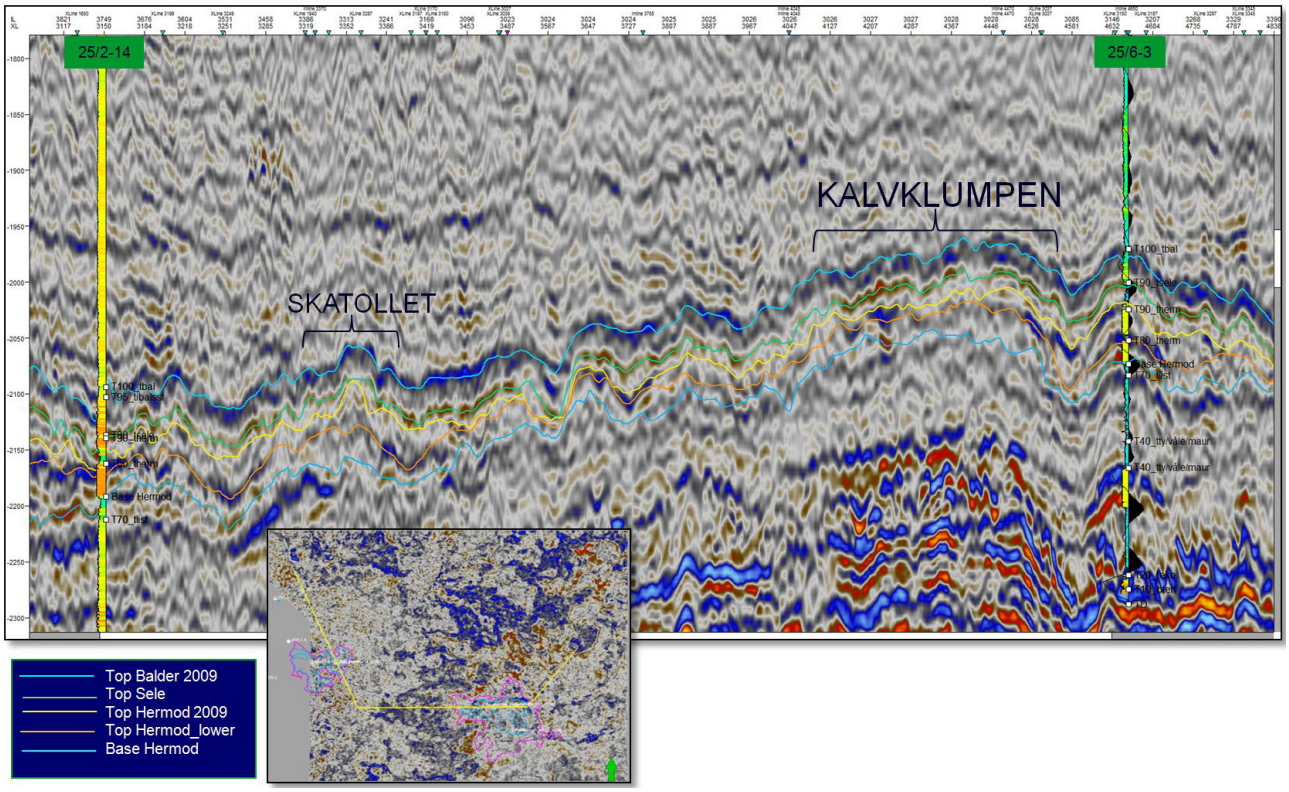

Fig. 3.2 Seismic section through Skatollet and Kalvklumpen

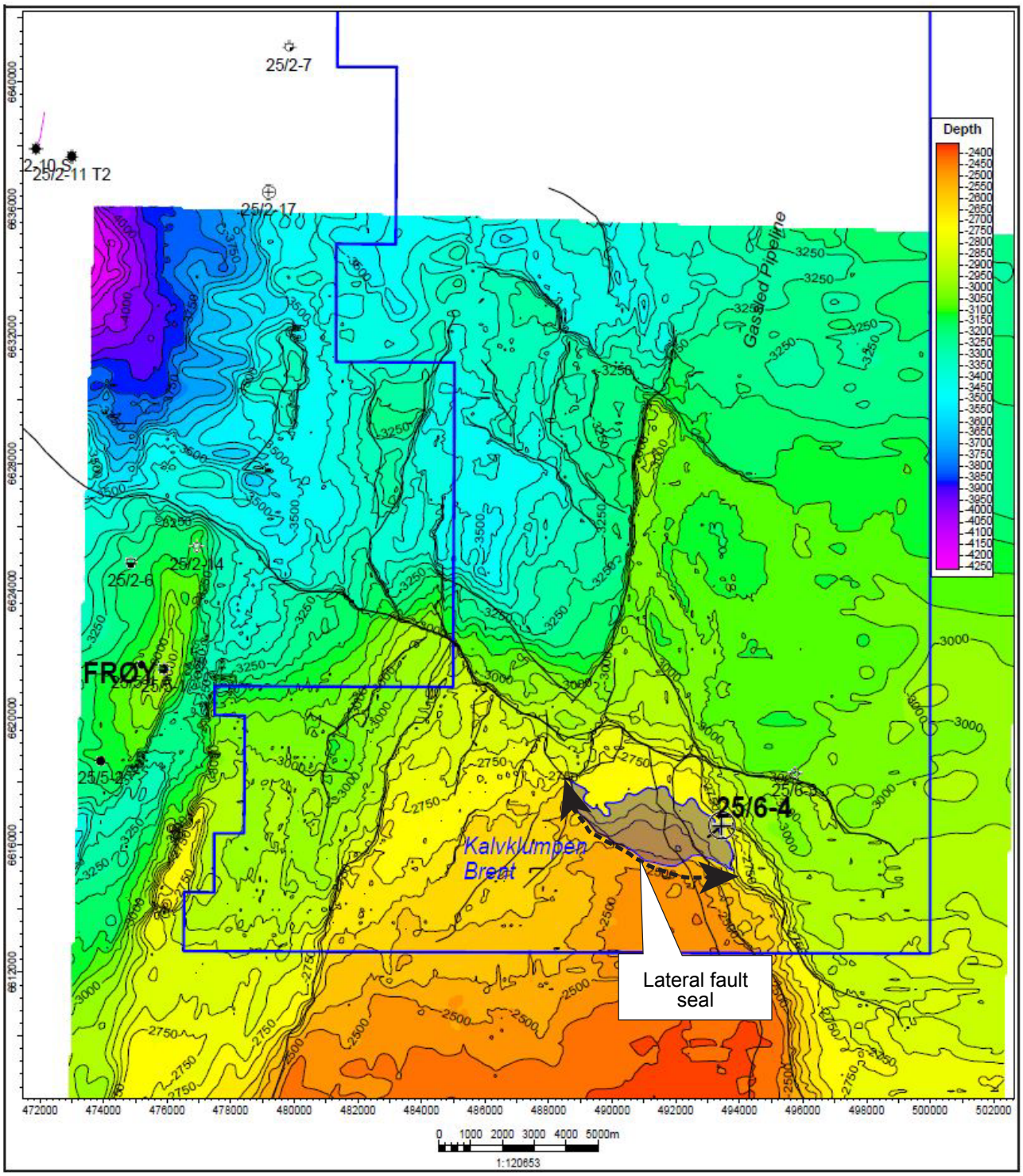

Fig. 3.3 Top Brent depth map

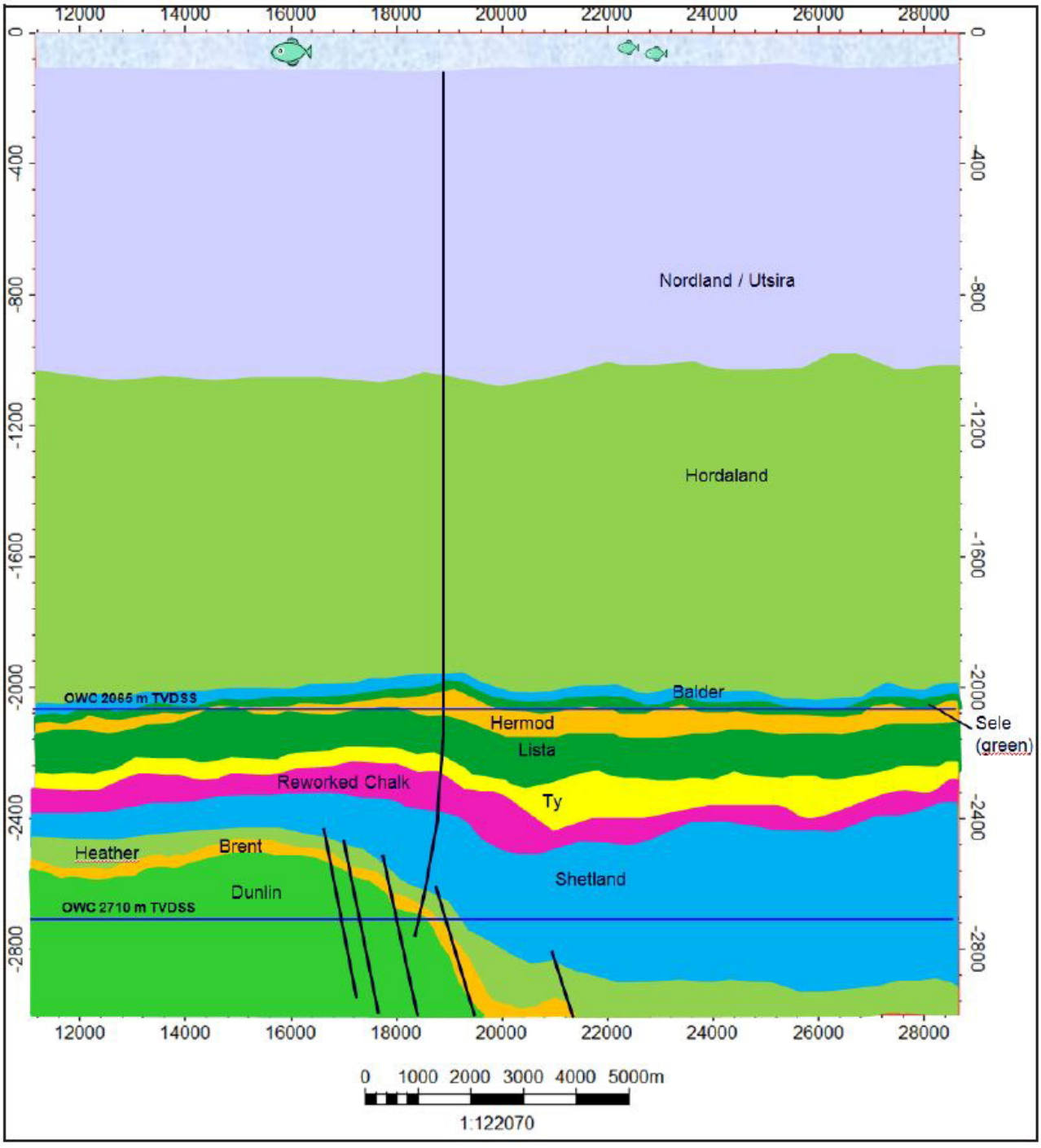

Fig. 3.4 Cross section over the 25/6-4 S Kalvklumpen well

3.2 Well 25/6-4S

3.2.1 Objectives

The well objectives for the 25/6-4S was to carry out all operations in a safe and cost efficient manner, without causing injury or ill health to any of the personnel involved and without any damage to the environment.

The main HSE objectives was:

- Establish the consortium HSE requirements for the well project
- Establish an efficient and co-ordinated HSE working process
- Contribute to effective risk management through continuous risk reduction
- Achieve 0 well control incidents

The well 25/6-4S objective was to investigate the hydrocarbon potential in the primary and secondary targets, the Paleocene Hermod Formation and the Mid Jurassic Brent/Vestland Group, and to fulfil NPD's regulations for data acquisition.
In case of discovery the plan was to core the reservoir section(s) and perform logging with an extensive wireline logging suite.

3.2.2 Well results

The semi submersible drilling rig Songa Delta drilled the 25/6-4 S well (Kalvklumpen prospect) in license PL414. The rig arrived on location the 7th of January 2012 and left the location on the 17th of February. Total time used on the well was 46.3 days (1111.5 hrs), waiting time was 17% (188.5 hrs) and accumulated downtime was 2% (23.5 hrs). Seabed is located at 114.5 m below MSL, 143.5 m RKB.
The well 25/6-4 S target was to test the hydrocarbon potential of the Late Paleocene Hermod Formation as primary target, and the Jurassic Vestland Group as secondary target in the Kalvklumpen prospect. No hydrocarbon shows were seen during drilling of the well. TD of the well was set in the Dunlin Group at 2950 m MD. The well was permanently plugged and abandoned on 15th of February 2012 as a dry well.

Table 3.2 shows the prognosed formation tops and actual penetration depths, while Fig. 3.5 illustrate the actual lithology and stratigraphy in addition to the planned and actual casing points for the reservoir section and the overburden, Fig. 3.6.

The main target, the Hermod Formation, was encountered at 2071 (2069 m TVD) and is found to be of excellent reservoir quality. An average porosity of 35.9% and net-gross of 87.5% are found, se petrophysical evaluation of logs, CPI Fig. 3.7. The Ty Formation consists of two massive sands with some calcite cementation. A poor sorting of the sand gives a porosity of 25.1%, lower than the well-sorted Hermod Formation. The secondary objective, the Vestland Group, came in at 2810 m (2670 m TVD). Well statistics for all reservoir zones are listed in table Table 3.1.
The Hugin Formation is poorly developed with a net-gross of 18.8%. However, the porosity is high in the thin sand stringers with an average value of 21.3%. The Sleipner Formation has high quality sands with a porosity of 23.7%. Due to significant distribution of coal and calcareous siltstone, the net-gross value is 47.3%. Water saturation is 95-100% in the all reservoir ranges, indicating no

residual hydrocarbon saturation. Some spike gas readings and saturations are seen in the coal-rich Sleipner Formation, but this is believed to be methane generated from the coals. Except for the coal layers in the Sleipner Formation, no fluorescence or oil stain is seen from the cuttings and very low gas readings were seen throughout the entire reservoir section, see CPI logs Fig. 3.8. In general, the total gas was low through the entire well, with very low to no content of heavier hydrocarbon components. No cores were cut and no wire line fluid samples were taken.

The presence and maturation of the source rock was not seen as a high risk. The highest risk prior to drilling was assumed to be the migration route and probably leakage through the top seal. The well results confirmed that the migration probably was the main failure.

Table 3.1 Actual and prognosed well tops

		Prognosis		Actual			
Group	Formation Name	mTVD-MSL	mMD-RKB	mTVD-MSL	mMD-RKB	Thickness	High/Low (-/+)
Nordland	Seabed	114	143	114.5	143.5	N/A	0.5
	Naust	114	143	114.5	143.5	513.2	0.5
	Utsira	658	687	627.7	656.7	348.6	- 30.3
	Undifferentiated	Not prognosed		976.3	1005.4	45.7	N/A
Hordaland	Undifferentiated	1054	1083	1022.0	1051.1	145.9	- 32.0
	Skade	1154	1183	1167.9	1197.0	60.1	13.9
	Base Skade/ Undifferentiated Hordaland	1314	1343	1228	1257.1	743.7	- 86.0
Rogaland	Balder	1961	1990	1971.7	2001.3	39.7	10.7
	Sele	2007	2037	2011.4	2041.4	29	4.4
	Hermod	2013	2043	2040.4	2070.8	62.7	27.4
	Sele	Not prognosed		2103.0	2134.5	6.5	N/A
	Lista	2084	2115	2109.6	2141.2	75.6	25.6
	Våle	Not prognosed		2185.1	2219.3	31.8	N/A
	Ty	2215	2252	2217.0	2253.2	36.6	2.0
	Våle	Not prognosed		2253.6	2293.1	43	N/A
Shetland	Reworked Chalk	2270	2311	2296.5	2341.5	59.7	26.6
	Top Shetland Gp	2387	2452	2296.5	2341.5	N/A	- 90.4
	Hardråde	Not prognosed		2356.3	2412.7	250.4	N/A
Viking	BCU/Draupne	2621	2782	2606.7	2759.7	26.2	- 14.3
	Heather	Not prognosed		2632.9	2797.7	8.2	N/A
Brent/Vestland	Brent/Hugin	2667	2849	2641.1	2809.6	21.6	- 25.9
	Sleipner	Not prognosed		2662.7	2841.0	40.3	N/A
Dunlin	Undifferentiated	2694	2889	2703.0	2899.5	34.8	9.0
	TD	2728	2939	2737.8	2950	N/A	9.8

Table 3.2 Well statistics for 25/6-4S

Zone Name		HERMOD FM	TY FM	HUGIN FM	SLEIPNER FM
Top	[m MD RT]	2070.8	2253.2	2809.6	2841.0
Bottom	[m MD RT]	2134.5	2293.1	2841.0	2899.5
Gross	[m MD]	63.7	39.9	31.4	58.5
Top	[m TVD MSL]	2040.4	2217.0	2641.1	2662.7
Bottom	[m TVD MSL]	2103.1	2253.6	2662.7	2703.0
Gross	[m TVD]	62.7	36.6	21.6	40.3
Net	[m TVD]	54.9	29.2	4.1	19.1
N/G	[v/v]	0.875	0.799	0.188	0.473
Av Phie	[v/v]	0.359	0.251	0.213	0.237
Av Swe	[v/v]	0.965	0.982	0.935	0.924
Arithmetric KLOGH	[mD]	2377.7	494.7	20.1	268.4
Geometric KLOGH	[mD]	2042.6	393.7	6.3	109.0

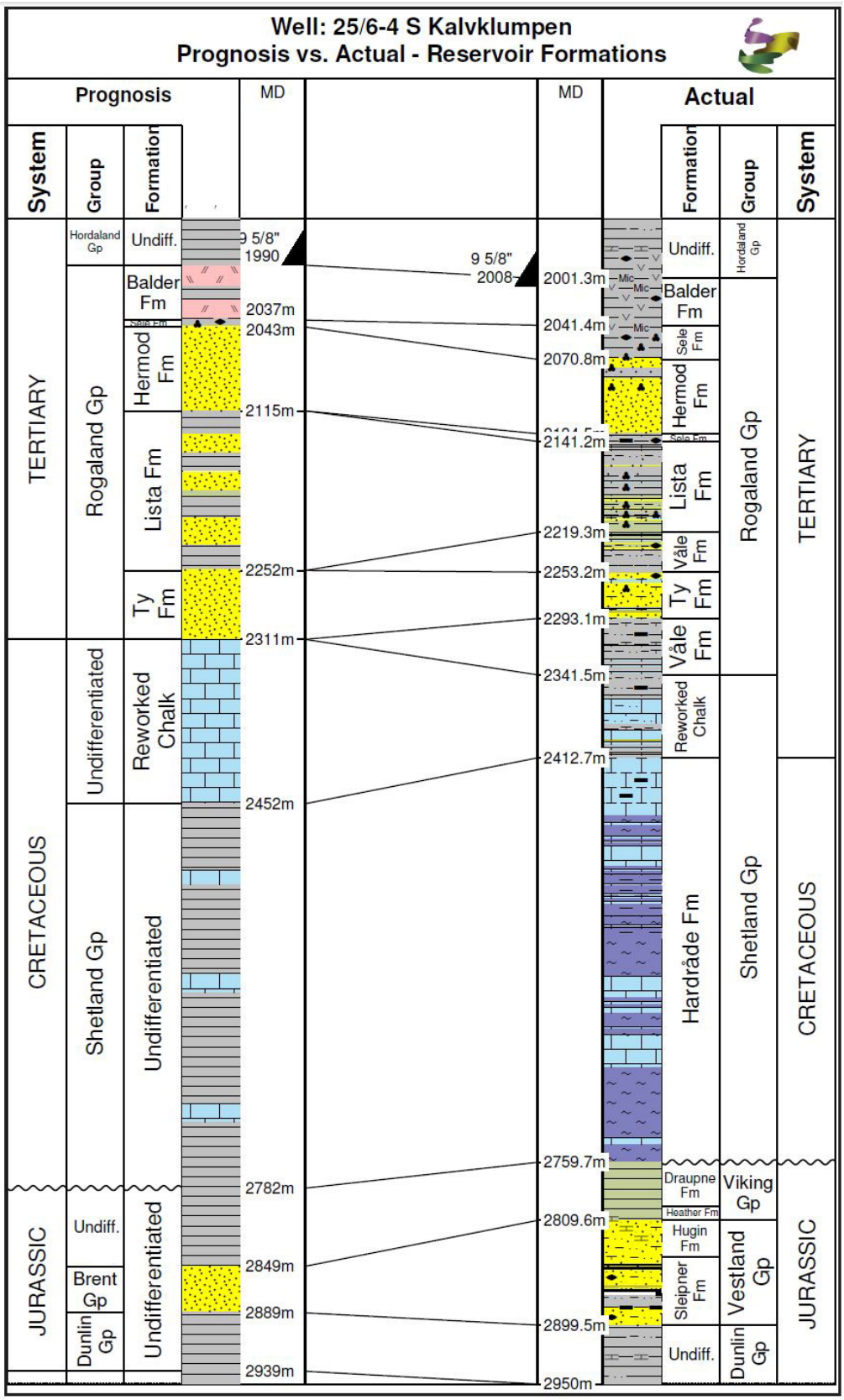

Fig. 3.5 Prognosed vs. actual stratigraphy

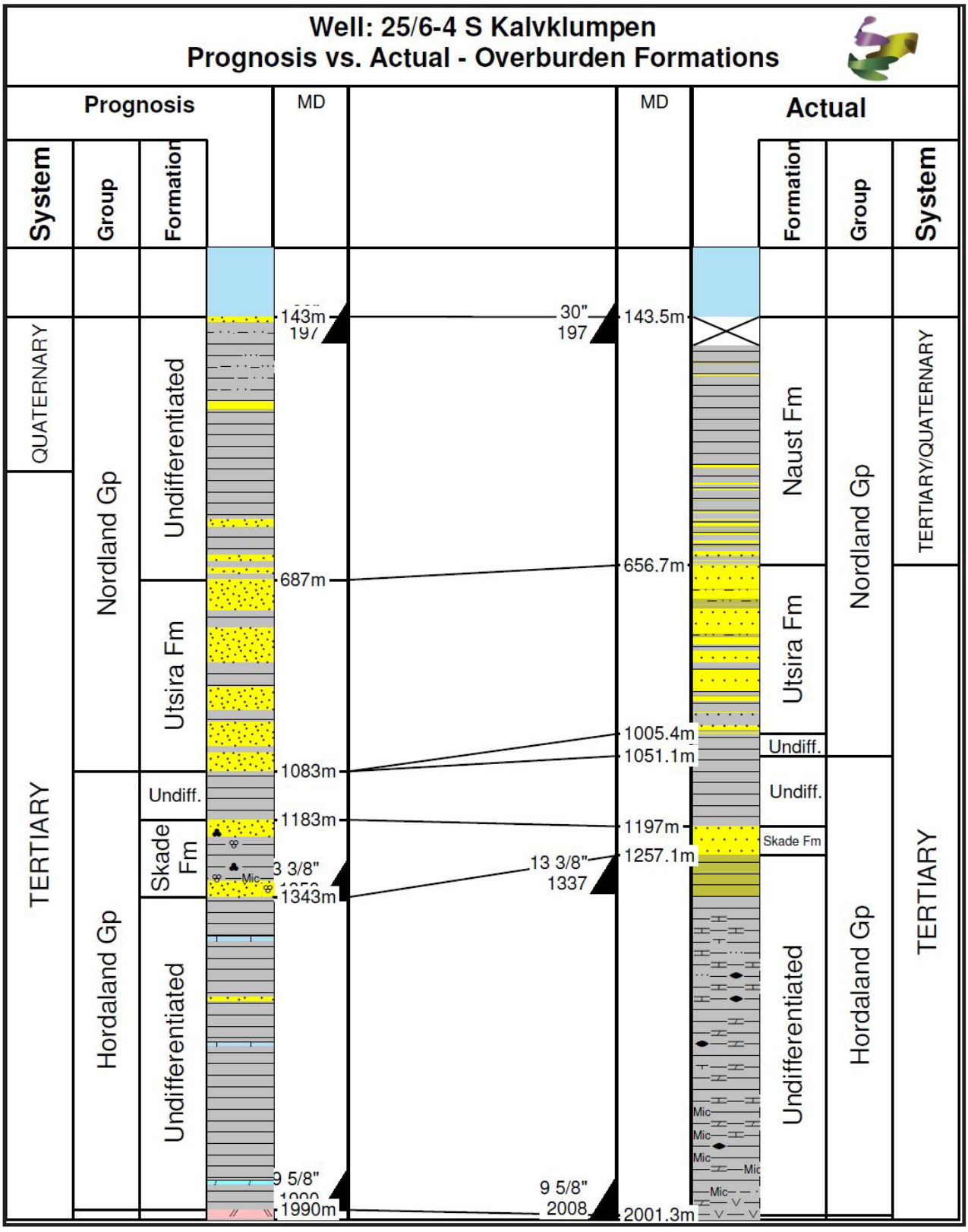

Fig. 3.6 Prognoses vs. actual stratigraphy for the overburden

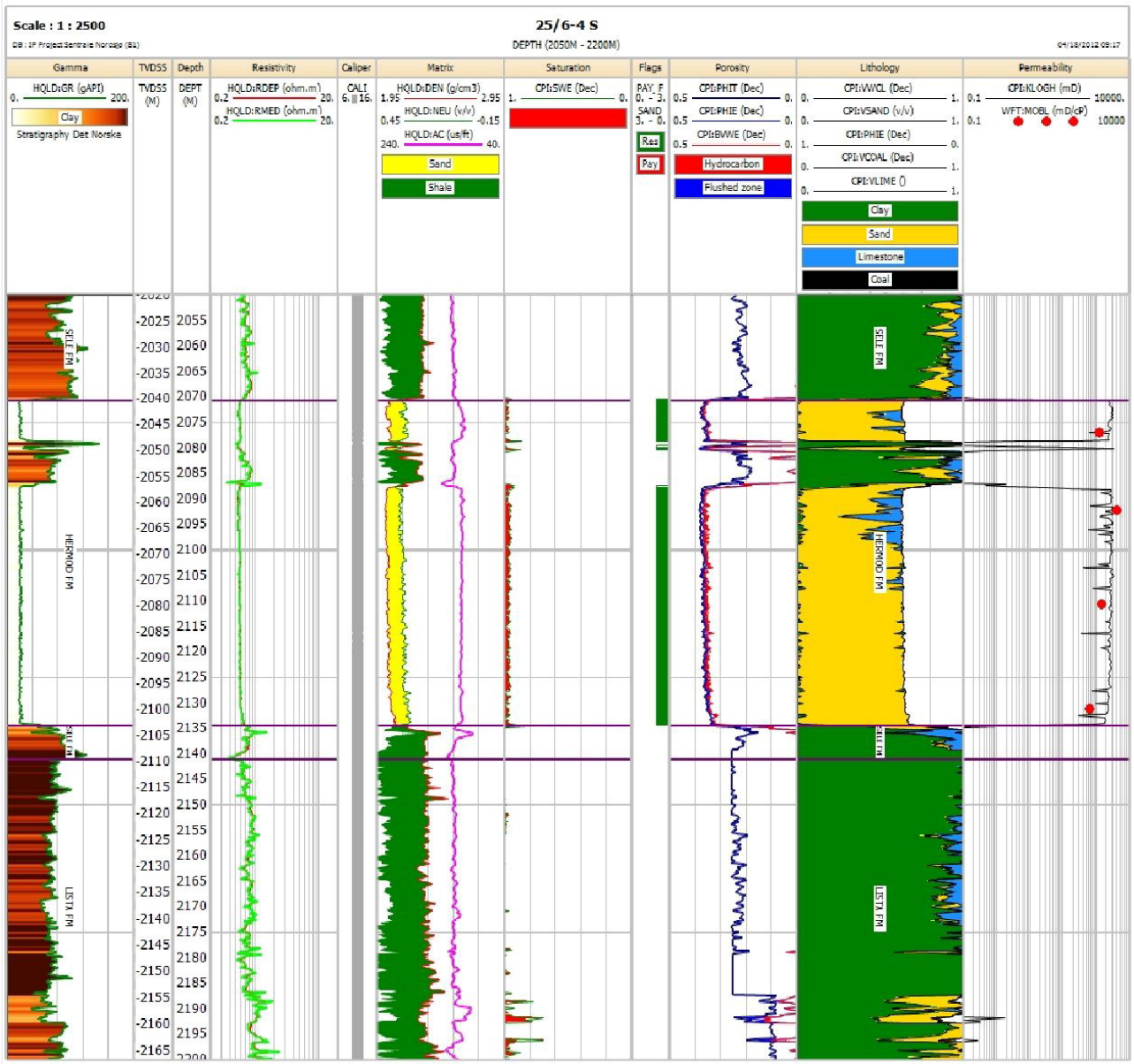

Fig. 3.7 CPI of the Hermod Formation

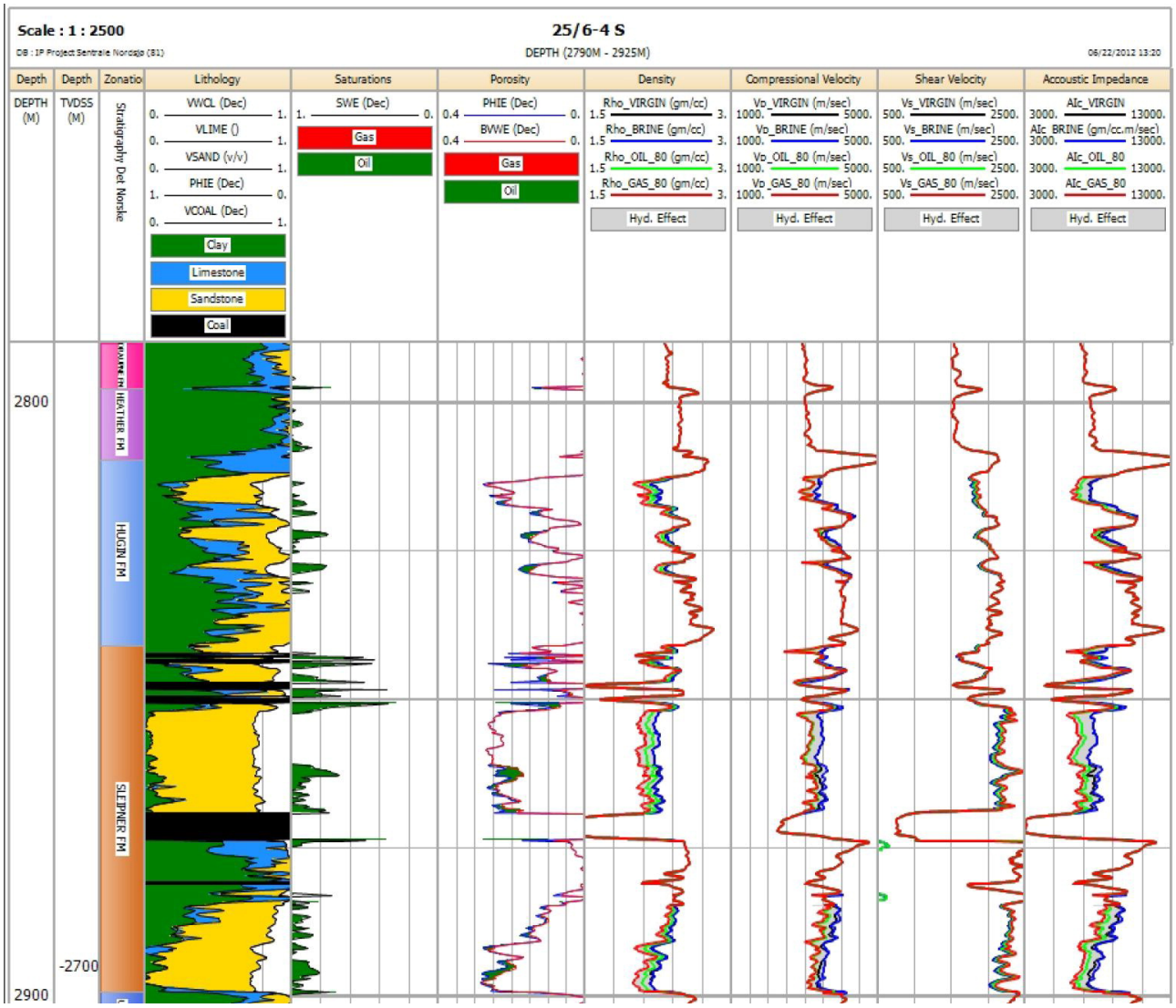

Fig. 3.8 CPI of the Hugin and Sleipner formations

4 REMAINING PROSPECTIVITY

The PL 414/PL 414B operator has carried out an evaluation of the remaining prospectivity in the licence and has matured one prospect (Oksen) and mapped several leads Fig. 4.1.

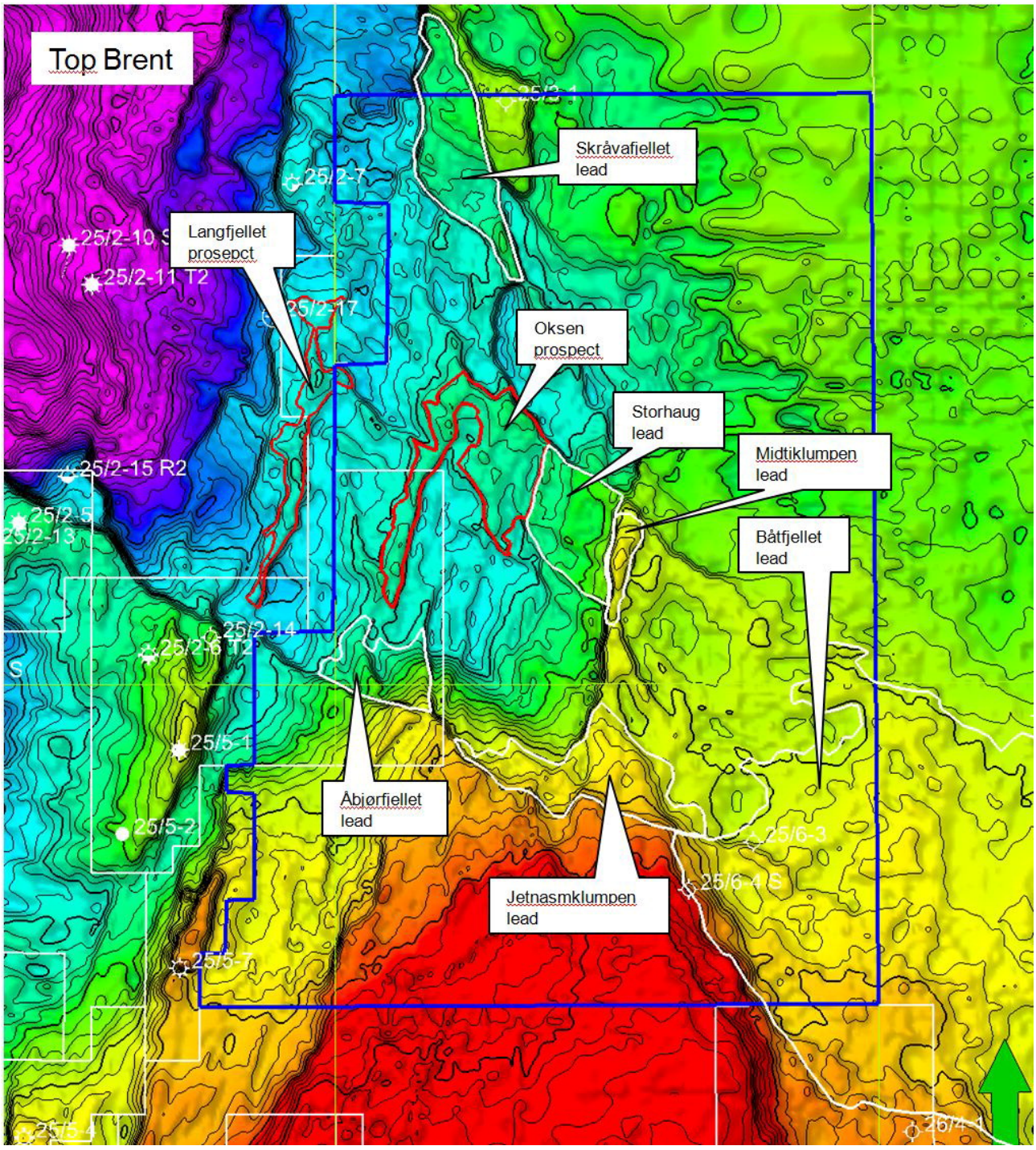

Fig. 4.1 Remaining prospectivity in the area showed on a top Brent map

The outline of the mature Oksen prospect is seen in map wiew in Fig. 4.2 and in the two cross sections going west-east Fig. 4.3 and south-north in Fig. 4.4. This is a small 4-way closure, a fault-bounded prospect, dependent on sealing fault to the east for commercial volumes. The reservoir is Brent/Vestland Group and not considered as a risk, supported by well documented reservoir in the area.

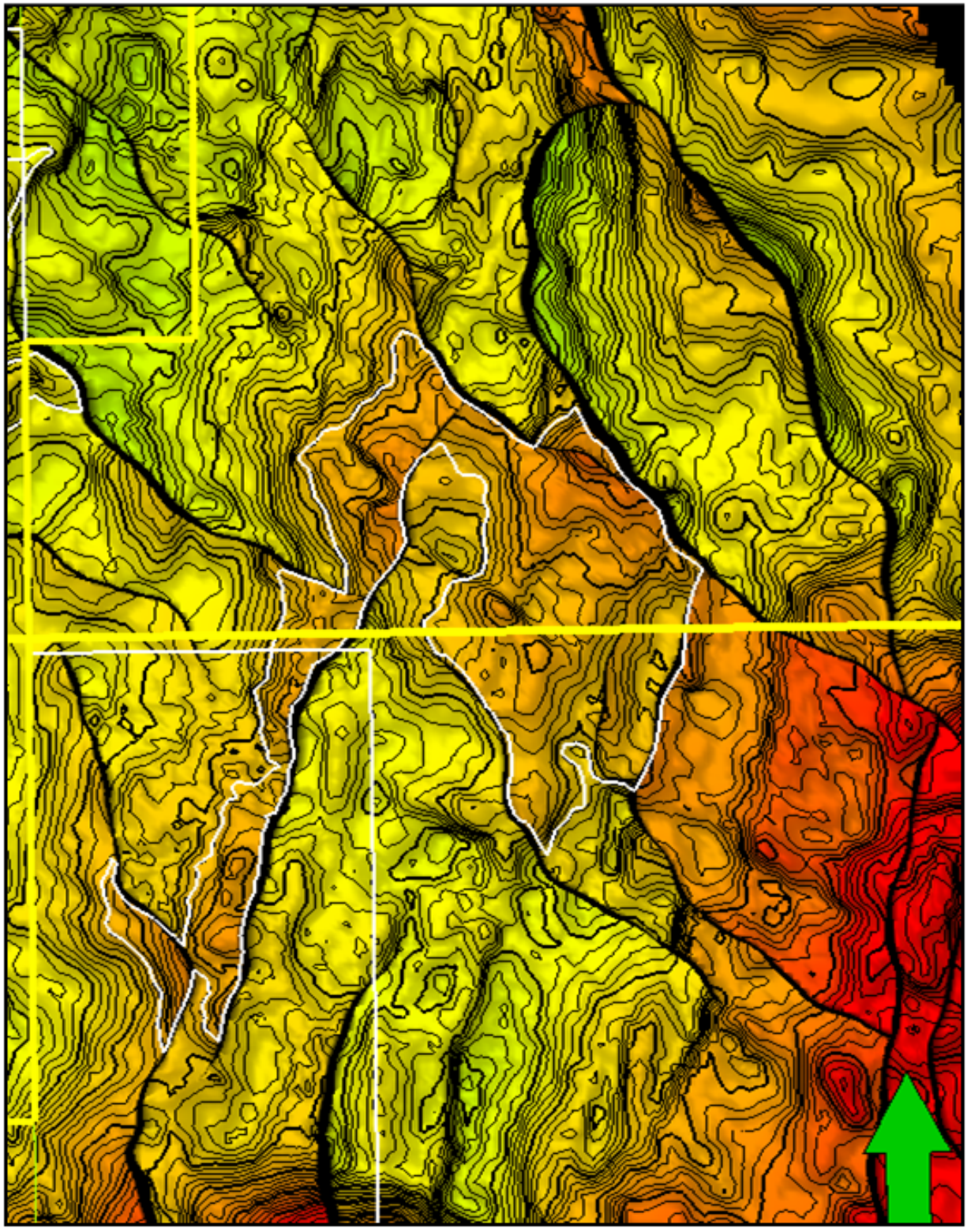

Fig. 4.2 The Oksen prospect on a top Brent map

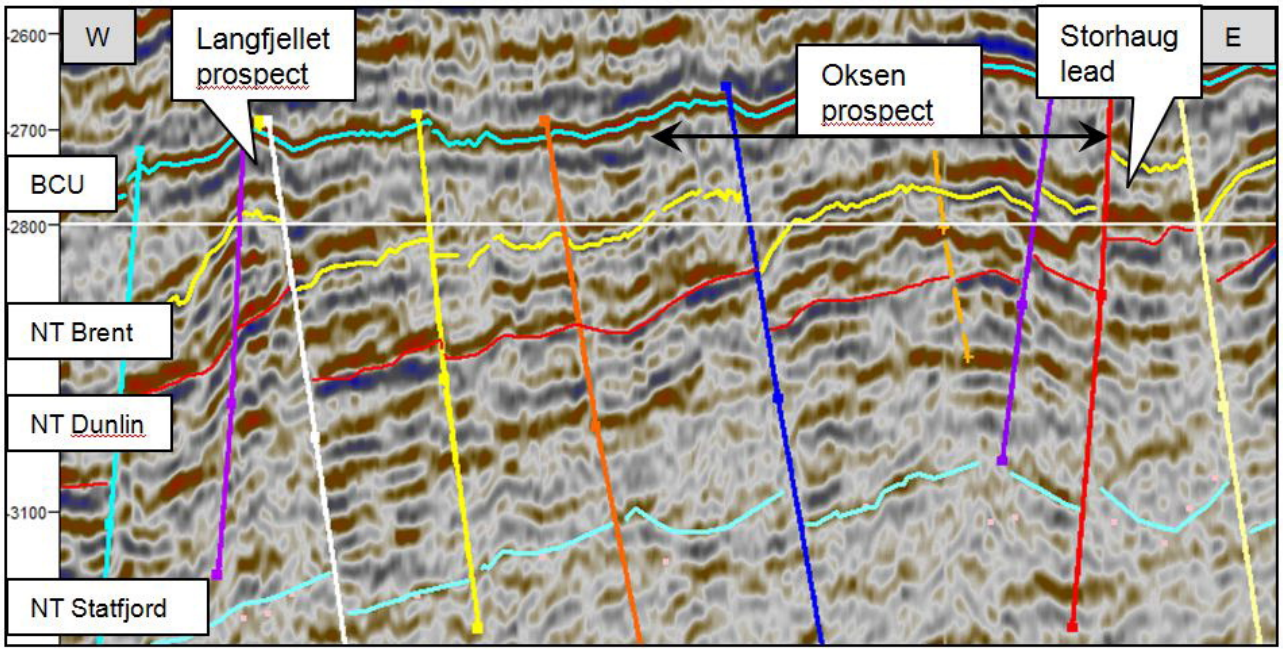

Fig. 4.3 West-east cross section through the Oksen prospect

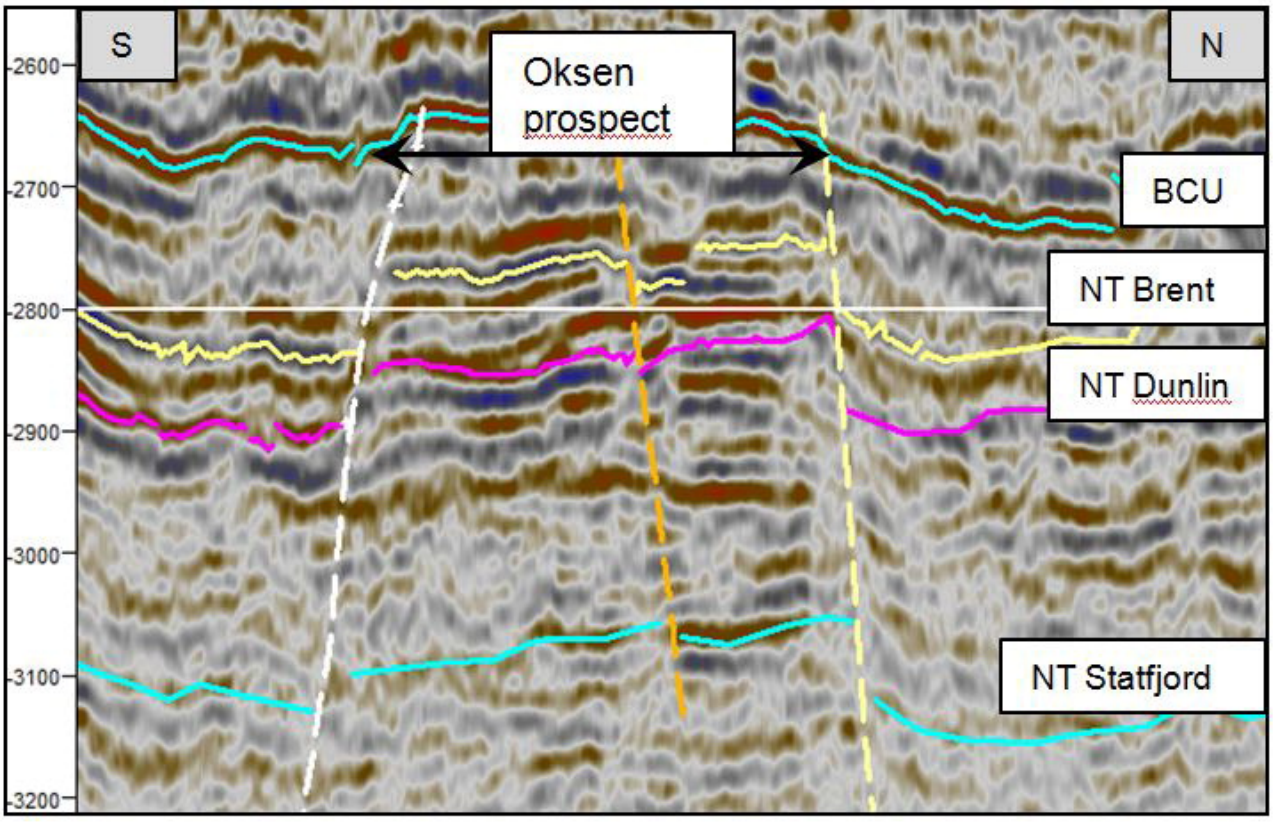

Fig. 4.4 South-north cross section through the Oksen Prospect

Basinal Draupne and Heather shales are the expected sources, and not considered a risk, given the presence of a working hydrocarbon system in the area. Migration is dependent on fill-spill from the Langfjellet prospect to the west, PL 442.

The Knubben prospect is situated above the Oksen prospect. This is a 4-way closure with reservoir section in the Hermod Formation, sealed by the Sele shale. Migration is considered to be the main risk due to likely spill into the shallower Frigg sands in the migration pathway.
The crest of the structure is located directly above Oksen (Brent Group) prospect. The Knubben outline is seen in Fig. 4.5 and a north-south cross line in Fig. 4.6

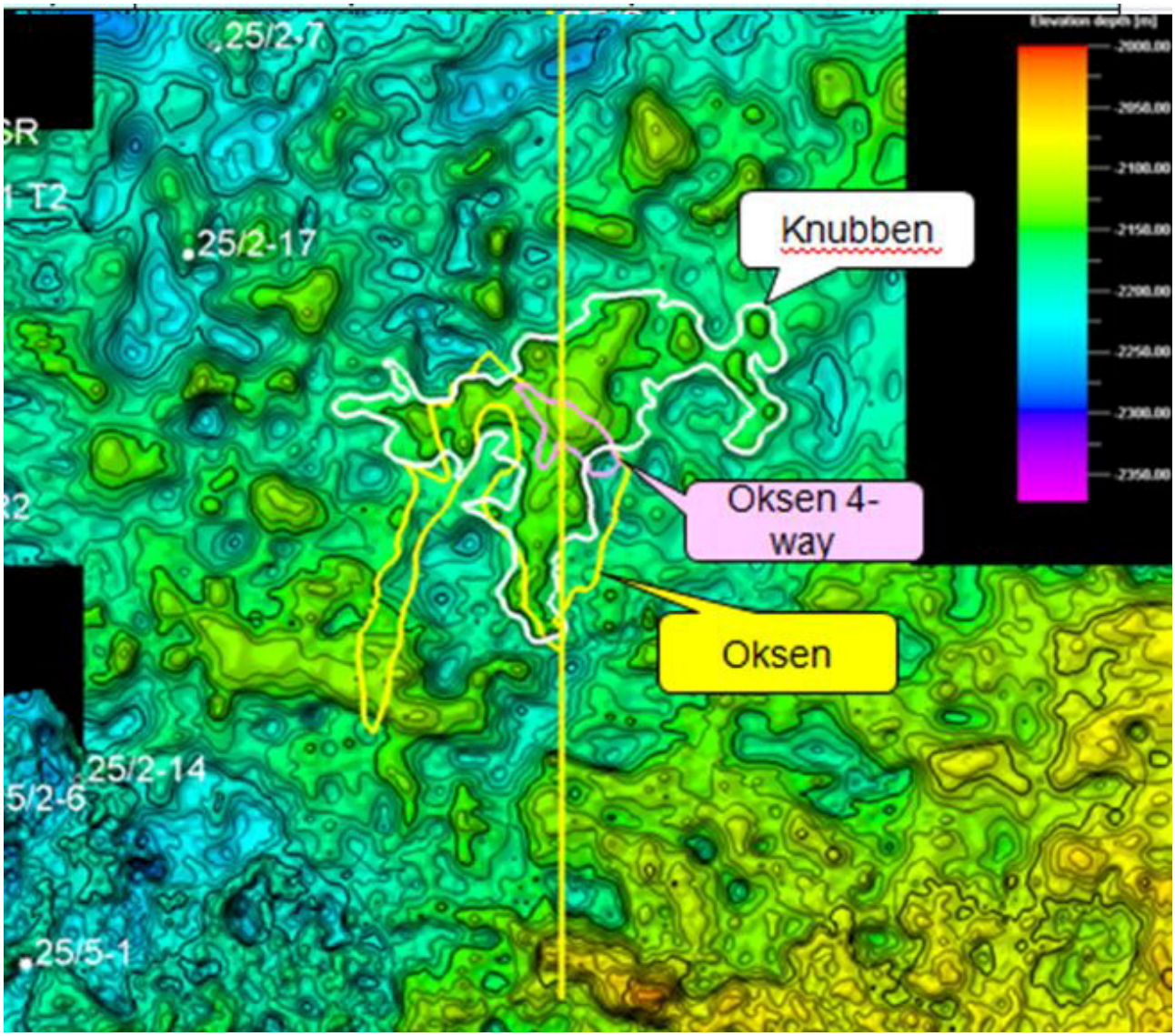

Fig. 4.5 The Knubben outline on a Hermod depth map

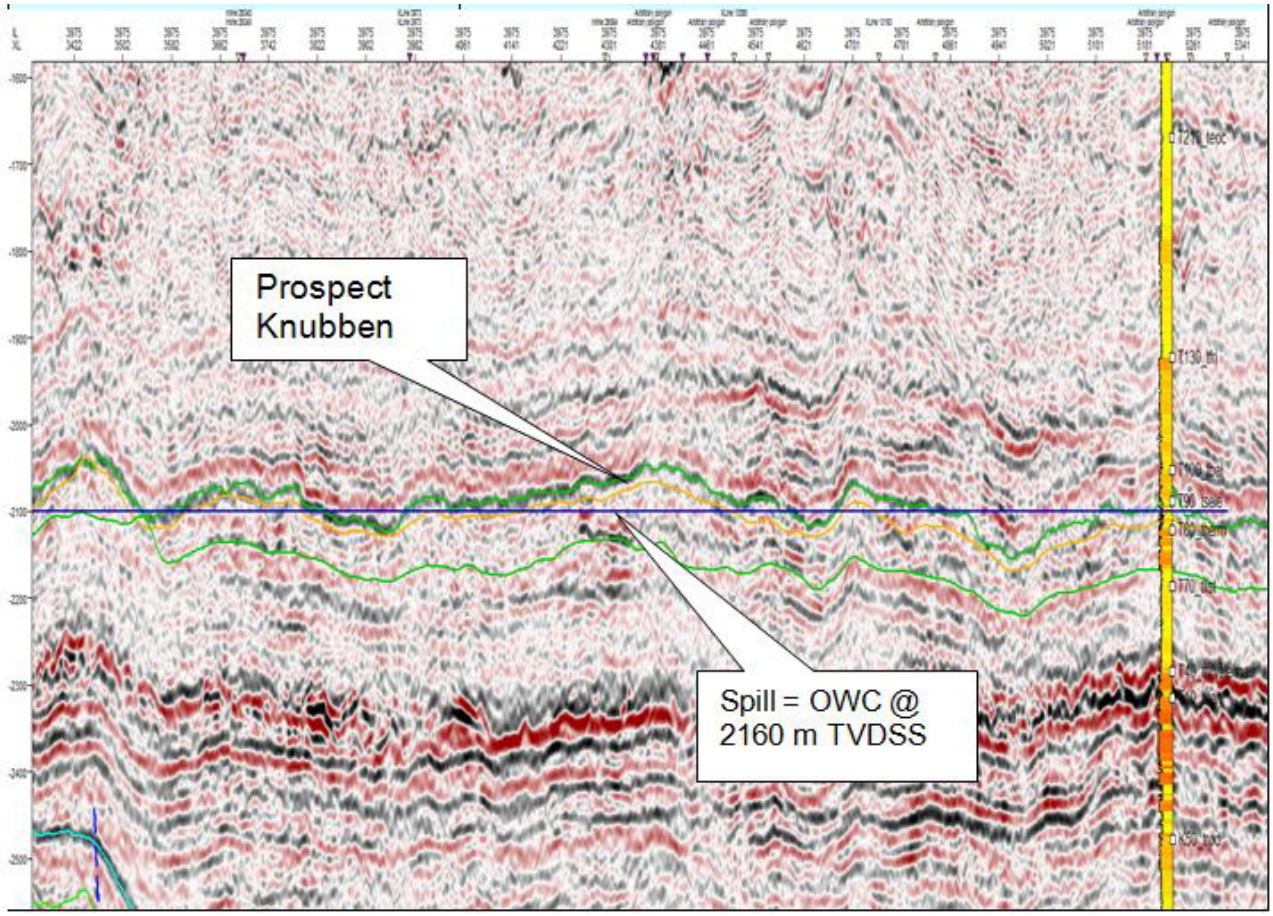

Fig. 4.6 North-South cross line through the Knubben prospect and 25/3-1

The expected recoverable reserves for the Oksen, Åbørfjellet, Litfjellet, Storhaug, Midtiklumpen, Jetnamsklumpen (Jurassic and Hermod), Skatollet and Knubben are presented in the table Table 4.1 .

Table 4.1 Expected recoverable reserves for the remaining prospects

PL 414					GROSS RECOVERABLE RESOURCES					
					Low		Mean		High	
CATEGORY	RESERVOIR LEVEL	HC	RF (%)	POS (%)	Oil (MSm3)	Gas (GSm3)	Oil (MSm3)	Gas (GSm3)	Oil (MSm3)	Gas (GSm3)
PROSPECTS										
Oksen	Brent Gp	Oil	40	32	0,6		6,1		12,2	
Åbjørfjellet	Brent Gp	Oil	40	16	0,8		7,3		12,9	
Litlfjellet	Brent Gp	Oil	40	20	0,2		0,9		1,5	
Storhaug	Brent Gp	Oil	40	27						
Midtiklumpen	Brent Gp	Oil	40	26	0,7		1,9		3,3	
Jetnamsklumpen Jura	Brent Gp	Oil	40	20	3,5		7,9		13,2	
Skatollet N	Hermod Fm	Oil	50	17	8,7		11,2		13,9	
Knubben 1+2	Hermod Fm	Oil	50	11	11,7		17,9		24,9	
Jetnamsklumpen	Hermod Fm	Oil	50	15	5,2		6,7		8,35	

The partnership of PL 414/PL 414B find the uncertainties related to migration and the structural trap with fault dependant spill-point to be of too high risk to drill the Oksen prospect, and therefore relinquish the license.