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RELINQUISHMENT REPORT

RELINQUISHMENT REPORT

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1 Summary of Licence History

The PL467S licence was awarded following the 2007 APA licencing round, to BG Norge (60% and operator) and VNG (40%), with an effective date of 29th February 2008. The initial work program was:

- Acquire 400sqkm of 3D seismic
- Make a drill or drop decision (DOD) before 28th February 2010

There was a stratigraphic split within the awarded blocks, with PL467S being restricted to below Top Cretaceous in part-block 35/7 and below Base Pliocene in part-block 35/5.

The voting rule for the licence was two parties and more than 50%. Regular licence meetings were held to discuss the seismic acquisition and reprocessing and the subsurface evaluation

Acquisition of 537sqkm of 3D seismic, was completed during August 2008 with the vessel 'Wavefield Endeavour'. The survey was extended beyond the original planned commitment area in order to cover the 35/8-1 well and hence give an additional calibration point for the key reservoir horizons. The initial fast-track time migrated seismic volume was available in early 2009, but at this time it became obvious that Pre-Stack Depth Migration (PSDM) processing was required to improve the structural image. The conventional Kirchhoff PSDM volume was delivered in October 2009, but it was then necessary to apply additional 'Beam Migration' processing to further improve the seismic image. A six month extension of the drill or drop decision to 29th August 2010 was granted to enable the full interpretation of the final seismic volumes.

The sub-surface evaluation benefitted from the operator's regional studies of the Cook Fm and Statfjord Fm reservoirs, which were designed to support the evaluations of PL467S, PL373S (Knarr), PL374 (Blåbær) and PL372S (Plomme).

The seismic acquisition was focused on the Boysenbær prospect, a large fault and dip closed prospect with reservoir potential within the Cook and Statfjord Formations. The 35/4-1 dry well was drilled on the flank of the structure in 1997. Interpretation of older seismic data, at the time of the 2007 licence round, indicated that the well may have been positioned outside of the structural closure at both reservoir levels. However, the evaluation of the new 3D seismic confirmed that the well was drilled within a valid structural closure and that the remaining potential was restricted to a limited up-dip volume and a smaller, southern fault block, which was only partly within the licence. The small in place volume potential, combined with risks related to possible trap breach and the marginal reservoir quality, significantly downgraded the prospect.

The licencees made a unanimous decision to relinquish the licence at the 29th August 2010 DOD deadline.

2 Database

2.1 Well database

All nearby wells, that were released at the time of evaluation were, included in the common database. The 35/4-1 well, drilled on the flank of the Boysenbær structure, is key for providing information about reservoir quality. The 35/8-1 well to the south was used to provide an additional calibration point for interpretation within the new 3D survey. Within the Boysenbær prospect the primary reservoir target was the Cook Fm and the wells drilled on the northern part of the Tampen Spur were important for the regional understanding of the Cook Fm.

2.2 Seismic database

Prior to the 2008 3D seismic acquisition the MC3D_NNS 'Megamerge' survey was used to evaluate the prospectivity.

The table below lists the final volumes that are available for the new 2008 acquisition. A fast track time migrated volume was generated, but a final time migrated volume was not created as it was decided that a time migration would not provide sufficient imaging improvement.

Survey Name
BG0806-PSDM-FULL-OFFSET-TIME
BG0806-PSDM-FULL-OFFSET-AGC-TIME
BG0806-PSDM-FULL-OFFSET-DEPTH
BG0806-PSDM-6-15-DEGREE-ANGLE-STK-TIME
BG0806-PSDM-15-24-DEGREE-ANGLE-STK-TIME
BG0806-PSDM-24-33-DEGREE-ANGLE-STK-TIME
BG0806-PSDM-VERY-FAR-OFFSET-TIME
BG0806-PSDM-BEAM-STK-TIME
BG0806-PSDM-VELMODEL-8KM
BG0806-STACKING-VELOCITY

3 Review of Geological and Geophysical Framework

The subsurface evaluation of the PL467S licence was focused on the Jurassic age Cook and Statfjord Formations. The potential for a Cretaceous age reservoir was recognised in the hanging wall syncline east of the Boysenbær bounding fault, but it was not possible to identify a valid trap.

The main change to the subsurface interpretation, during the licence period, came with the delivery of the final processing of the new 3D seismic, which showed that the 35/4-1 well had been drilled within a valid structure at the Boysenbær prospect. There was no major change to the understanding of reservoir distribution or source/migration history.

3.1 Reservoir

The range of Jurassic reservoir quality uncertainty, at the Boysenbær structure, was relatively tightly constrained as a result of the proximity to well 35/4-1 and there was no major change in the understanding of reservoir quality distribution during the licence evaluation. There was a general improvement in the understanding of the main reservoir fairways as a result of the operator's regional reservoir studies.

Brent Formation

The Brent Fm is present in the 35/4-1 well as a silt and claystone facies with a few poor quality sandstone stringers, hence it is not considered as a potential reservoir target. The Brent Fm has been considered as a possible 'thief zone' in the evaluation of gas migration into the other possible reservoirs.

Cook Formation

The Cook Formation was evaluated as the main potential reservoir interval within the licence. The best Cook reservoir penetrated to date lies over the northern part of the Tampen Spur, in the vicinity of the Knarr discovery. In the Knarr area the Cook Fm is a high quality reservoir facies with clean sandstones and good permeability. The Cook reservoir facies degrades to the south due to an increase in the proportion of inter-granular fines. This is shown in the Vsh logs in the well correlation panel in Fig. 3.1. The presence of this additional fine grained material accelerates the loss of primary porosity with burial. A comparison of the Cook Fm gross and net sand thickness maps (Fig. 3.2 and Fig. 3.3) reveals this trend. Gross sand thickness is calculated using only a 50% Vsh cutoff and approximates the thickness of sand originally deposited. The net sand map uses a 10% porosity cut-off, in addition to the 50% Vsh cut-off. The difference between the two maps approximates the thickness of potential sandy reservoir that has been degraded to non-reservoir, by porosity loss during burial. The Boysenbær prospect is interpreted to lie at approximately the southern limit of the viable Cook fairway and the only net reservoir occurs in intervals of cleaner sand.

It should be noted that the Cook Fm Vsh response cannot be linked directly to reservoir quality. For example, apparently clean sands can have quite poor reservoir properties if a high proportion of feldspathic detrital grains are originally present. The feldspar is replaced with diagenetic clays during burial leading to the formation of a low permeability secondary porosity network. However, the main cause of the southwards decrease in reservoir quality in the Cook Fm appears to be the increasing 'rattiness' of the sands.

The range of Cook Fm reservoir properties at the Boysenbær structure is relatively tightly constrained by the adjacent 35/4-1 well. The well has a relatively low net to gross of 32%, despite the use of an optimistic 10% porosity cut-off. The conventional core, which was cut in the upper part of the Cook Fm, has permeabilities in the range 0.01-6mD.

Statfjord Formation

The Statfjord Fm was considered as a possible secondary target, however it has rather poor reservoir properties. In the 35/4-1 well the Statfjord Fm reservoir is at ca. 4700m and the reservoir quality has been quite severely degraded. There are only a few thin beds of net reservoir and permeability measurements are in the range 0.01-1.5mD

Fig. 3.1 Fig. 3.2 Fig. 3.3

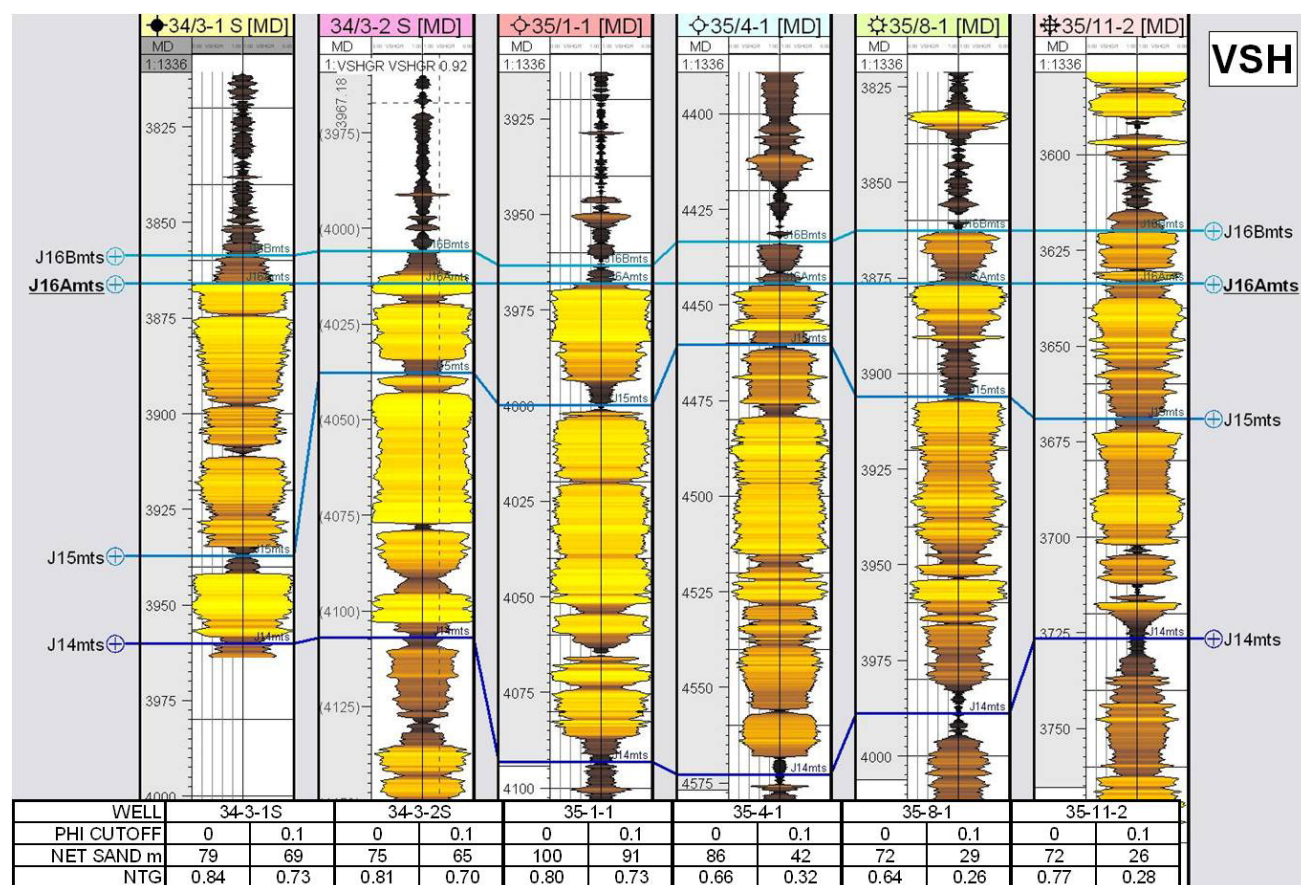


Fig. 3.1 North-South Vsh Correlation through the Cook Fm.. Vertical scale in metres. J16Amts and J14mts correspond to top and base Cook Fm respectively. The line of well section is shown on the net sand thickness map.

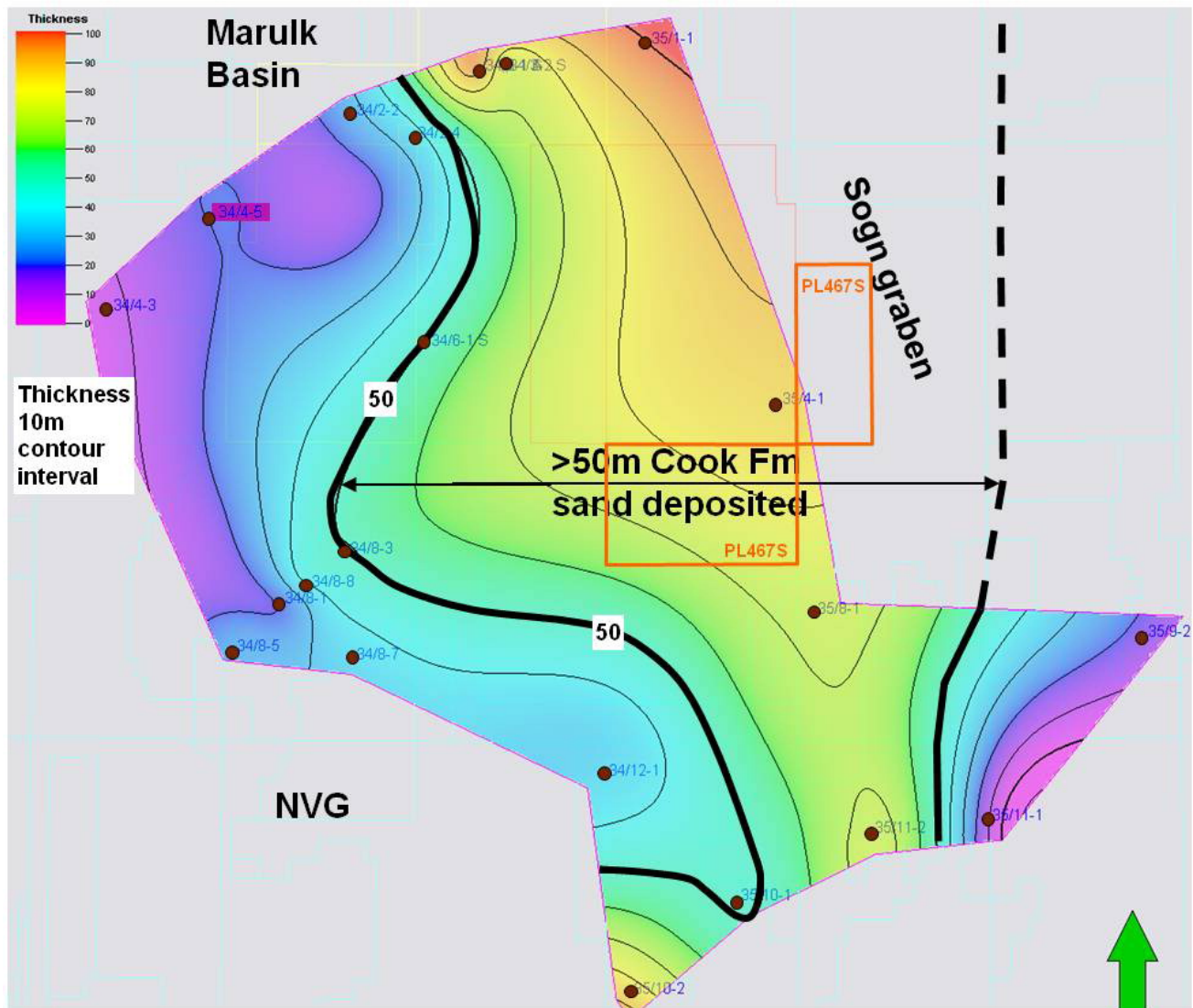


Fig. 3.2 Cook Formation Gross Sand Thickness Map. Approximates thickness of potential sandy reservoir originally deposited (map is tightly restricted to areas with well data). There is a comparable thickness of Gross sand over PL 467 and the Knarr wells to the North, where the Cook Fm is a high quality reservoir.

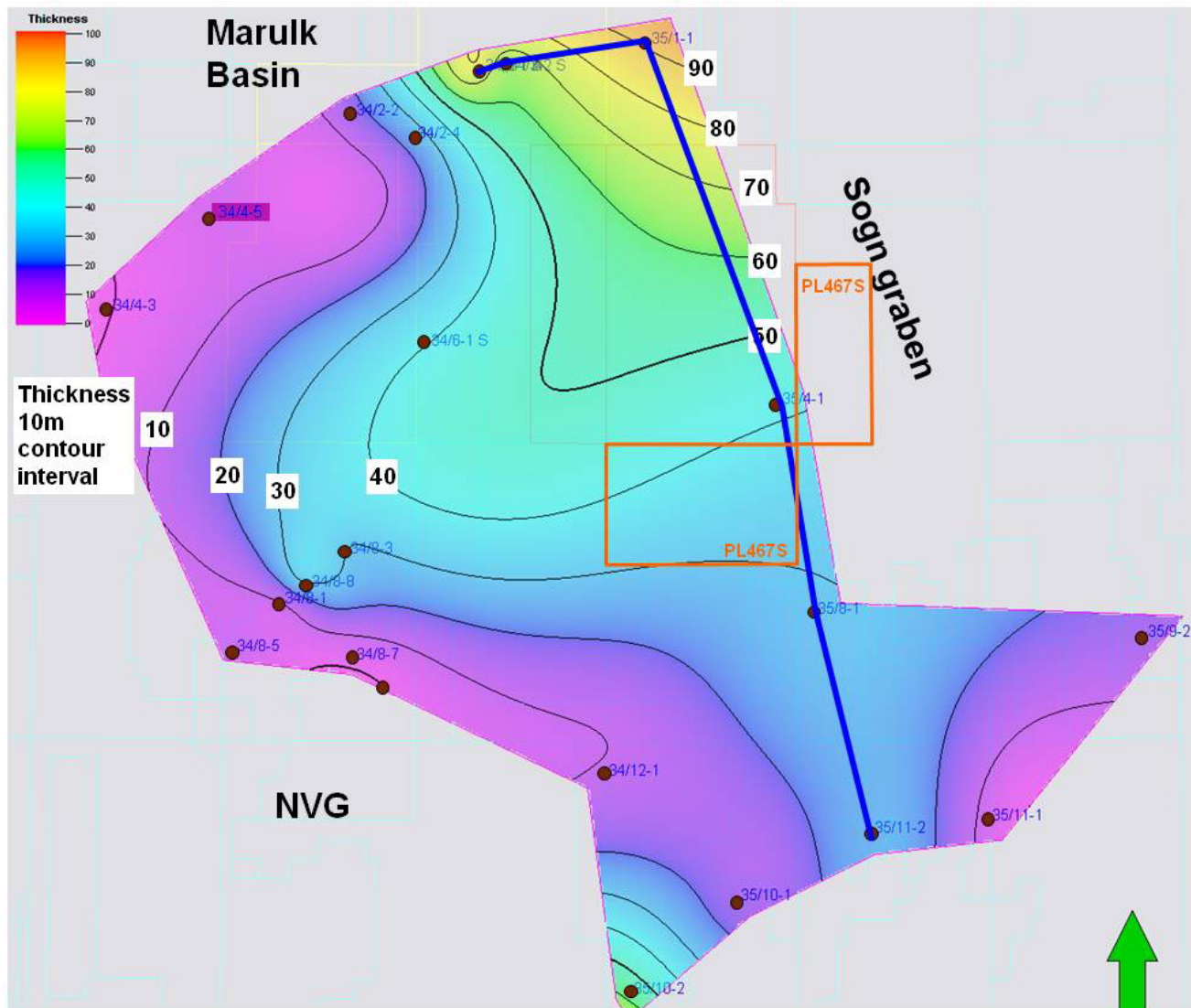


Fig. 3.3 Cook Formation Net Sand Thickness Map. 10% porosity and 50% Vsh cut-offs applied.

3.2 Trap

Trap Configuration

Re-mapping of the trap was the most significant change to the interpretation of the Boysenbær Prospect during the licence period. The newly acquired seismic was processed using PSDM and this helped to improve the poor imaging over the northern part of the Boysenbær structure. The poor seismic imaging is believed to be caused by an overlying shallow channel complex and a possible gas escape feature, which mask the key Jurassic reflectors. The PSDM processing helped to reduce the masking and improve reflector continuity.

At the time of licence application the prospect was mapped on the Northern North Sea 'Megamerge' volume and the existing 35/4-1 well was interpreted to have been drilled outside structural closure at the level of the Cook Fm. Critically, a small fault was picked just west of well 35/4-1, placing it in a downthrown hanging wall, just beneath the level of the maximum structural closure at top Cook Fm level. This interpretation is shown in Fig. 3.4. The structure of the Statfjord Fm parallels the Cook Fm and it was also believed that the well was drilled outside of closure at the level of the Statfjord reservoir.

The critical small fault is not an obvious pick on the Megamerge cube, which has poor imaging in this area. However, invoking the fault made it possible to avoid picking horizons against the grain of structural dip, within the masked seismic, and to create a consistent interpretation of the main Jurassic reflectors, which were calibrated by the 35/8-1 well to the south and had to be extended into the masked area to match the 35/4-1 well formation markers.

On the new data (BG0806 PSDM), the interpretation of the jump correlation, out of the 35/8-1 fault block, indicates that the Jurassic horizons west and south of Boysenbær were originally picked too high. The updated lower picks tie well with the markers in 35/4-1 and it is not necessary to invoke the small fault to create a consistent interpretation. In fact there is no evidence for the fault on the new seismic volume so it has been removed from the interpretation model. The updated top Cook Fm map is shown in Fig. 3.5 and indicates that the 35/4-1 well is positioned within a valid structural closure, ca 145m up dip from the southern spill point. Examples of the different seismic vintages and interpretations are shown in Fig. 3.6, Fig. 3.7 and Fig. 3.8. The 'Beam Migration' was particularly successful at improving the seismic image around the 35/4-1 well. The well is also believed to have penetrated a valid closure at Statfjord level, which has an almost identical structural form to that of the Cook Fm.

Another update to the structural interpretation was the extension of the major fault, which separates the northern and southern fault blocks, to connect with the main bounding fault. The 35/4-1 well was drilled on the northern fault block; the Boysenbær south fault block remains untested.

The key untested structures remaining are the Boysenbær South fault block and the potential up-dip accumulation in Boysenbær North (above the level of the 4415m 'water up to' in the Cook Fm at the 35/4-1 well).

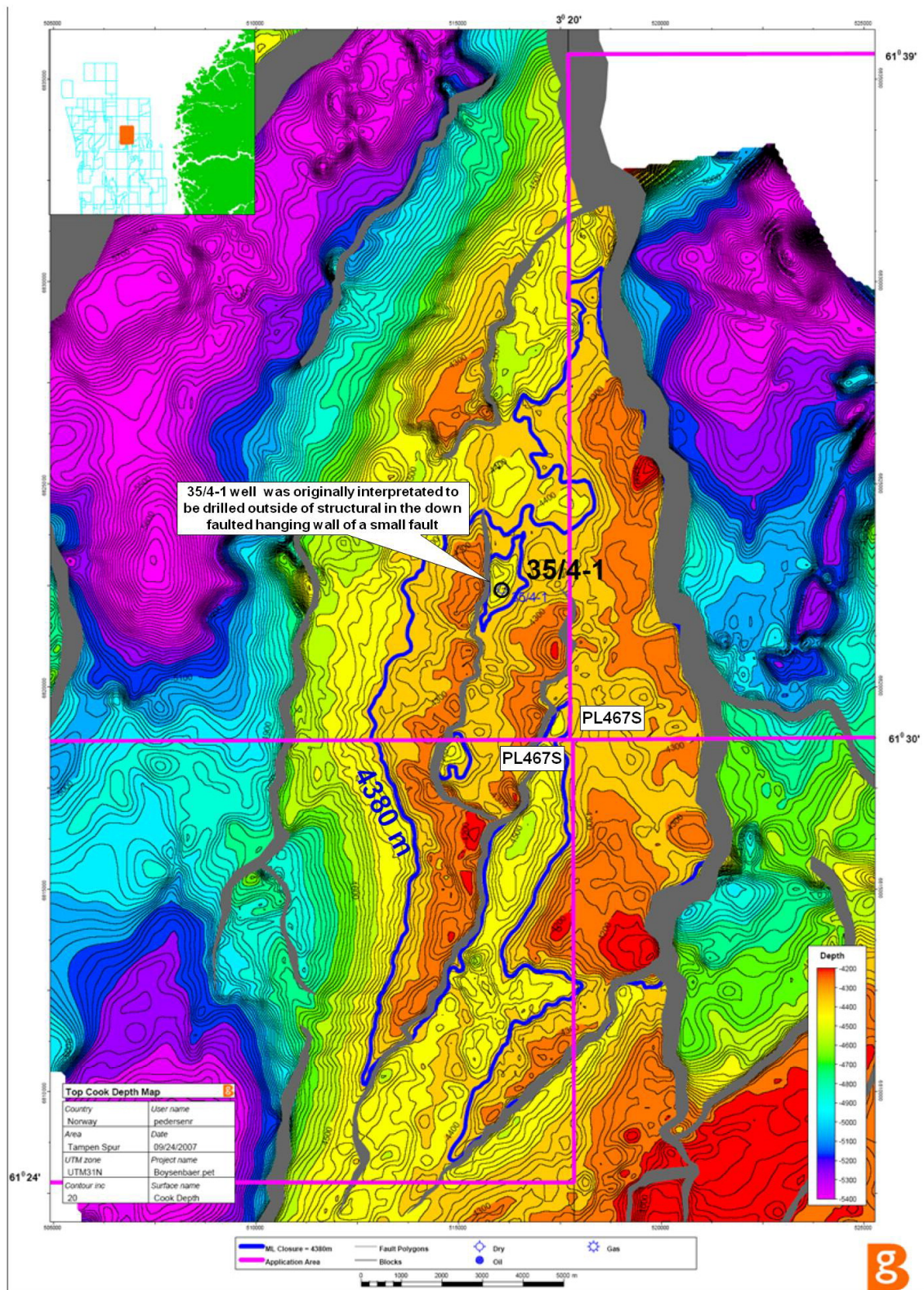


Fig. 3.4 Original Top Cook Fm Depth map. Interpretation based on vintage megamerge seismic. The 35/4-1 well appears to be drilled just outside closure on this map.

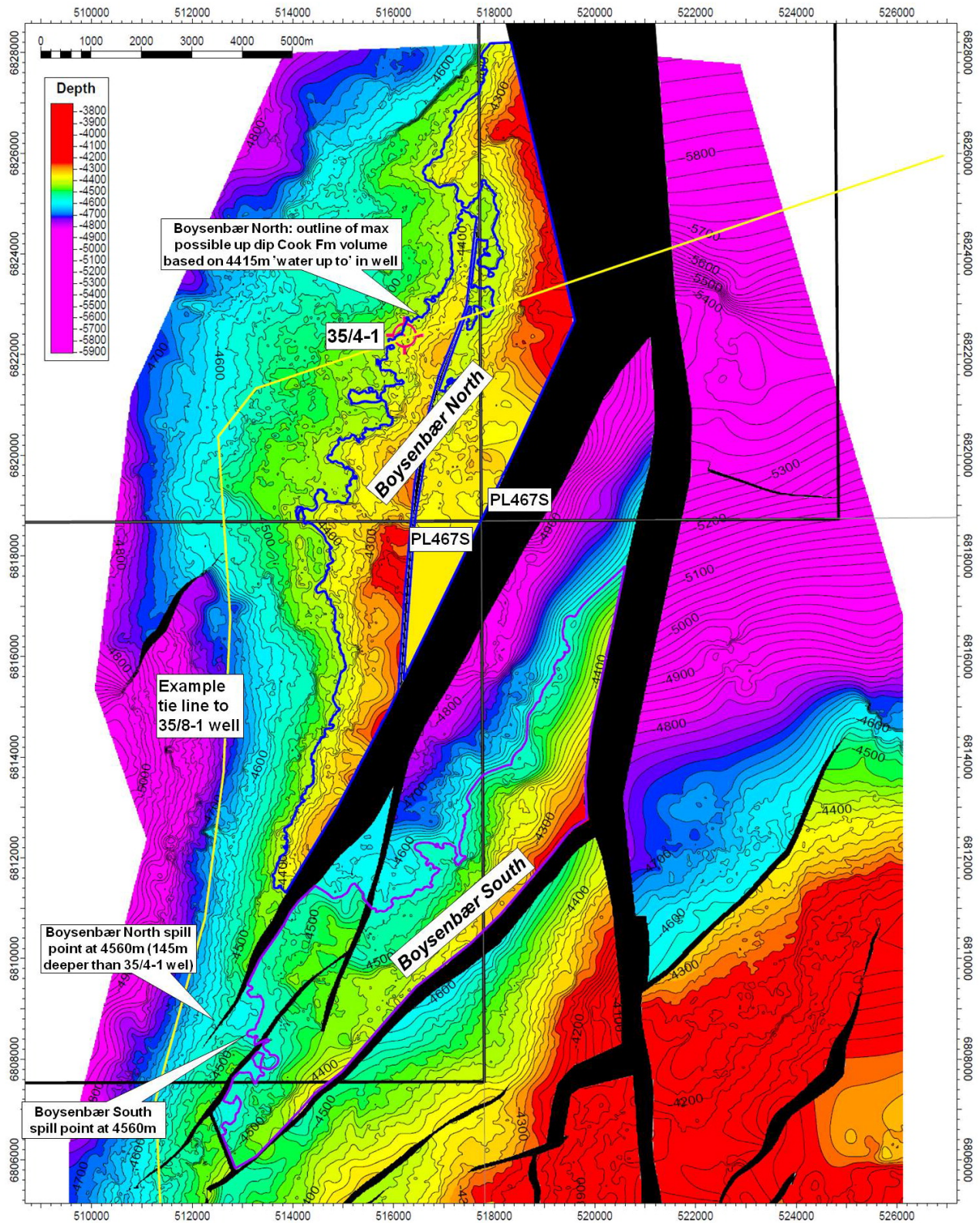


Fig. 3.5 Updated Top Cook Fm Depth Map. Shows that the 35/4-1 well lies within a valid structural closure at the level of the Cook Fm reservoir. The outlines of the updated Cook level prospects are also shown

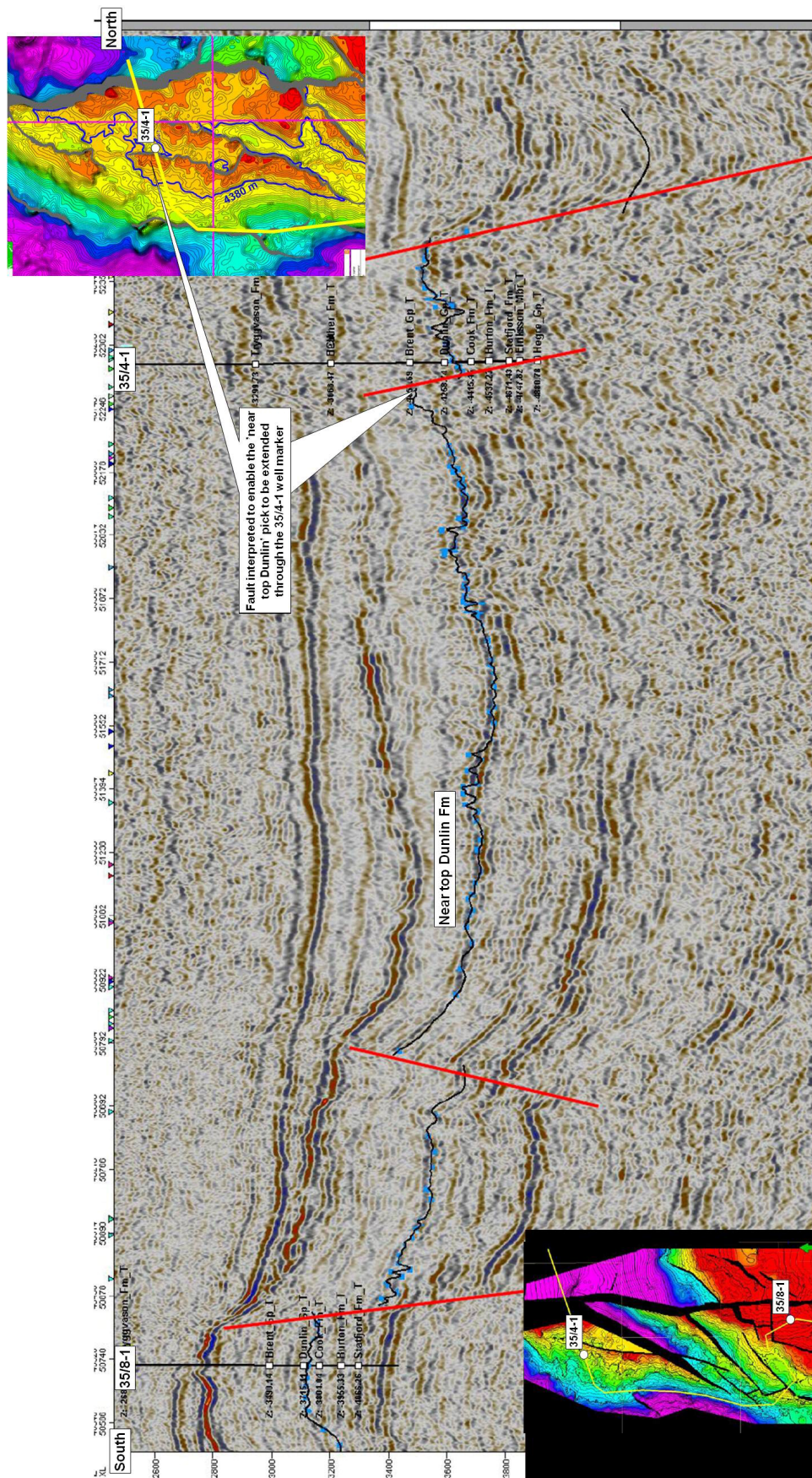


Fig. 3.6 Original Interpretation on 'Megamerge' 3D Seismic. Original interpretation, with a fault to the west of the 35/4-1 well.

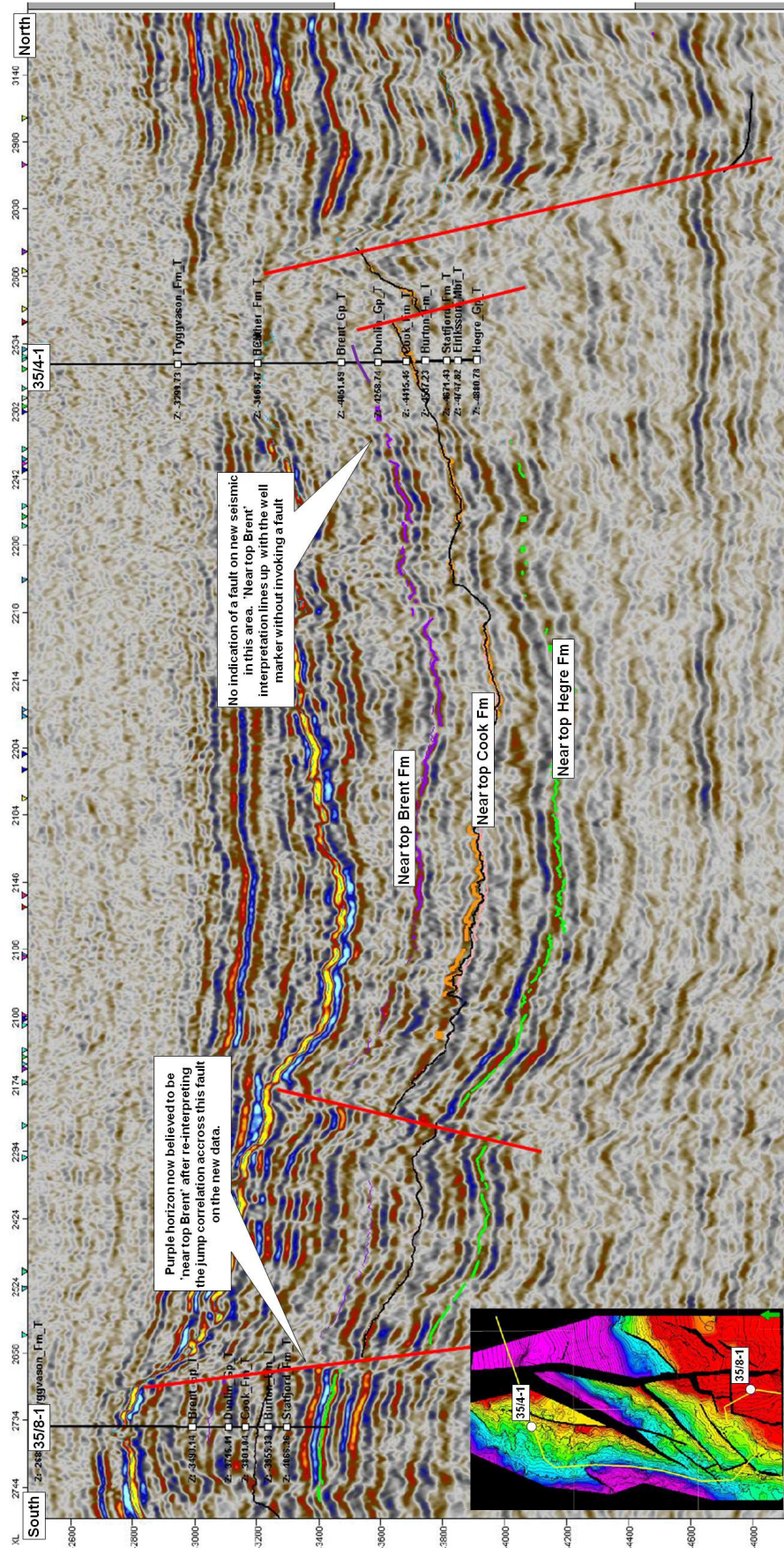


Fig. 3.7 Updated Interpretation on 2008 Seismic with PSDM Processing. Showing updated 'jump correlation' out of the 35/8-1 fault block and no fault interpreted to the west of the 35/4-1 well.

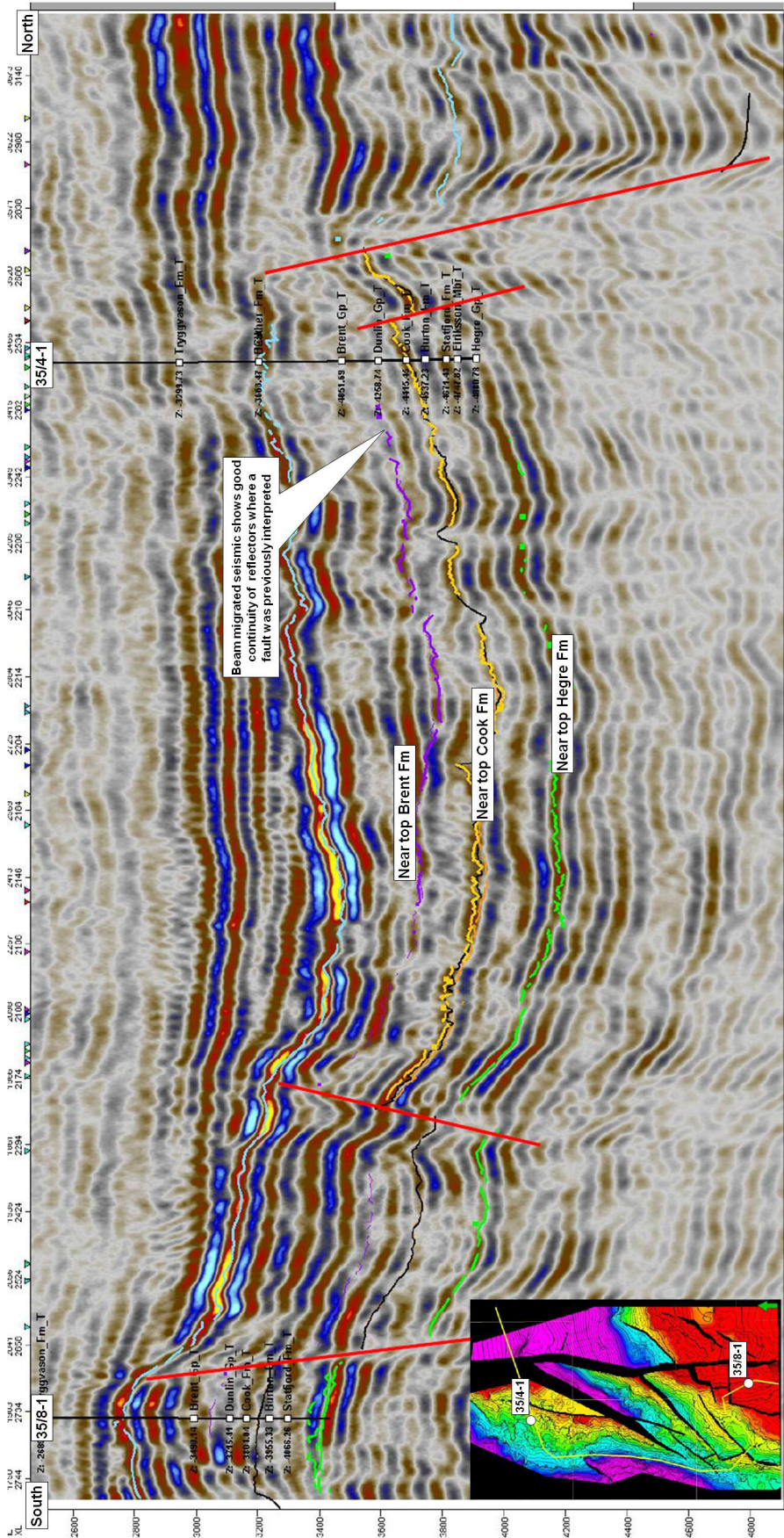


Fig. 3.8 Updated Interpretation on 2008 Seismic with PSDM 'Beam Migration' Processing. Gives improved imaging around the 35/4-1 well which suffered from masking on previous datasets. There is good reflector continuity, west of the well, where a fault was previously interpreted.

Trap Integrity

The poor seismic image over the northern part of the 'Boysenbær North' fault block may be caused by gas escape. It is unclear if the gas release originates from one of the Jurassic sandstones in the Boysenbær Structure or if it sourced from the deeper basin to the East. If gas is leaking from either the Brent, Cook or Statfjord intervals, it could explain why the 35/4-1 well did not encounter a live hydrocarbon column, despite being drilled within a valid structural closure. Gas leakage from one of the Jurassic reservoir intervals is likely to have been the result of hydraulic seal failure caused by reservoir overpressure, which could have been enhanced by 'lateral transfer' from one of the adjacent deep basins and/or the presence of a gas column. Overpressures 70% beyond the normal hydrostatic gradient were encountered in the 35/4-1 well, but several hundred bars of additional overpressure would have been required for reservoir pressure to exceed the fracture gradient and breach the seal. This additional overpressure may have been present at the time of seal breach and then subsequently lost with the gas leakage.

The presence of a gas chimney over the crest of the Boysenbær North prospect does not rule out the possibility of a live hydrocarbon column being present up dip from the 35/4-1 well. A partial fill scenario, with a stable equilibrium between gas escape and migration, is a plausible model. However, it is difficult to constrain the range of possible Hydrocarbon contacts and a very wide range has been used in the volume calculation.

3.3 Source and Migration

The Upper Jurassic age Heather Formation is the main potential source rock and its presence over the Boysenbær structure is confirmed by the 35/4-1 well. The Upper Jurassic Draupne Fm source rock is likely to be present down flank from the Boysenbær structure, where there is less erosion at the Base Cretaceous Unconformity (BCU). The two main source rock intervals are interpreted to be mainly gas mature within the drainage area of the Boysenbær structure. A possible gas chimney over the structure gives an additional reason to expect gas as the dominant phase.

The Upper Jurassic source rocks are stratigraphically shallower than the Lower Jurassic reservoir intervals, which creates a significant migration risk. The Cook Fm reservoir is overlain by ca. 350m of Drake Fm and Brent Fm claystones, which are likely to have acted as a barrier to the direct downward migration of hydrocarbons between the Heather Fm source rock and the Cook Fm reservoir. The Heather, Brent and Drake Fms combined are likely to have acted as an even stronger barrier to downwards migration between the Draupne Fm and Cook Fm. Faults, which juxtapose source against reservoir facies, are believed to be the only viable migration pathways from the Upper Jurassic source rocks into the lower Jurassic reservoir intervals. There are many faults within the Boysenbær drainage area, which have the appropriate juxtaposition of source and reservoir, but the limited combined surface area of these contacts is likely to have restricted the quantity of hydrocarbons migrating into the Cook Fm reservoir.

An additional risk for migration into the Cook Fm reservoir is the presence of the overlying thin sands and silts of the Brent Fm, which may have acted as a thief zone. Hydrocarbons within the Cook Fm may have been lost into the Brent Fm, where the intervals are juxtaposed at faults. In the Vega fields, to the South, hydrocarbons have accumulated in the Brent Fm, which is the shallowest Jurassic reservoir, but are generally absent in the Cook and Statfjord Fms. It is unclear if this is due to a limited downward migration or the Brent Fm acting as a thief zone or a combination of both.

The Drake Fm cannot be ruled out as a lean source rock, but it is unlikely to have had sufficient generative capacity to fully charge the Boysenbær fault blocks.

The 35/4-1 well was included in a 'Fluid Inclusion Stratigraphy' study. A sandstone thin section from 4451.1 mMD in the Cook Fm had several, white-fluorescing, upper moderate gravity light oil inclusions and several, blue-fluorescent, gas-condensate inclusions. This indicates that gas and oil are likely to have migrated through the reservoir at some time and a live hydrocarbon column may have been present at the well location.

The poor seismic image over the northern part of the 'Boysenbær North' fault block may be caused by gas escape. It is unclear which Jurassic sandstone interval the gas chimney is rooted on or if it sourced from the deeper basin to the East. The presence of this gas escape feature is interpreted as a positive indicator of a working petroleum system.

The 35/4-1 well was drilled within a valid structural closure and failed to find a live hydrocarbon column within any of the Jurassic sandstone formations. As discussed in the previous chapter, trap breach is a possible cause of the dry hole, but lack of sufficient migration into the Cook and Statfjord reservoirs is another possible well failure mechanism.

4 Update of Resource Potential

At the time of licence application the Boysenbær structure was the only recognised prospect. Following re-mapping, on new 3D seismic, it is now clear that the Boysenbær structure is divided into two separate fault block prospects: 'Boysenbær North' and 'Boysenbær South' (Fig. 3.5)

The updated interpretation shows that the 'Boysenbær North' fault block has been penetrated, by the 35/4-1, well within structural closure. The remaining potential is a possible 'attic' volume up dip from the existing well. There is a wide range of uncertainty on the position of the GWC contact and this is reflected in the large volumetric range. In the maximum contact scenario 25% of the prospect lies outside the PL467S area.

Since it has been demonstrated that the 35/4-1 dry well is drilled inside a valid structural closure, it has been necessary to increase the migration and trap integrity risks for the remaining prospectivity.

The 'Boysenbær South' fault block remains undrilled and has been modelled as full to spill in the volumetric calculation. Despite its relatively large volumetric potential, Boysenbær South is likely to be beyond the southern limit of the viable Cook Fm reservoir fairway. In addition, only half of the prospect lies within the PL467S area.

Prospect volumes have only been generated for the Cook Fm reservoir. At the time of licence application the Nansen member of the Statfjord Fm was believed to be a potential reservoir and was included in the prospect volumetrics. However, due to the difficulty of migrating hydrocarbons downwards in to the Statfjord Fm, it is now interpreted as a very high risk reservoir and has not been included in prospect volumetrics.

The table shows a comparison of the most recent Boysenbær volumes and those calculated at the time of licence application.

Recoverable resources	P90	Mean	P10	P90	Mean	P10
	Main Phase (Gas) 10 ⁹ sm ³			Associated Phase (Condensate) 10 ⁶ sm ³		
Boysenbær at licence application Cook and Statfjord reservoirs	12.8	22	33	2.0	4.1	6.4
Boysenbær North updated Cook reservoir only	0.444	2.74	6.03	0.186	1.21	2.67
Boysenbær South updated Cook reservoir only	7.73	9.53	11.4	2.74	4.23	5.8

The updated prospect summary sheets are shown in Fig. 4.1 and Fig. 4.2.

Block	Prospect Name			Discovery / Prospect / Lead		Prosp ID (or new)	NPD approved
35/4, 35/5 & 35/7 (up to 25% of prospect lies outside PL467S in the deep GWC case)	Boysenbær North (remaining potential up dip from well 35/4-1)			Prospect		NPD will insert data	NPD will insert data
Play (name/new)	Structural element			Company / reported by / Ref doc.			Year
NPD will insert data	Tampen Spur			BG Norge AS			2012
Oil/Gas case	Resources IN Place						
Gas condensate case	Main phase			Ass. Phase			
	Low	Mid	High	Low	Mid	High	
Condensate 106 Sm3				0.465	3.03	6.68	
Gas 109 Sm3	0.691	4.21	9.25				
	Resources RECOVERABLE						
	Main phase			Ass. Phase			
	Low	Mid	High	Low	Mid	High	
Condensate 106 Sm3				0.186	1.21	2.67	
Gas 109 Sm3	0.444	2.74	6.03				
	Which fractiles are used as:		Low	P90	High	P10	
Type of Trap	Water Depth (m)		Reservoir Chrono (from - to)		Reservoir Litho (from - to)		
Dip / fault closed	380		Late Pliensbachian - Toarcian		Dunlin Gp: Cook Fm		
Source Rock, Chrono	Source Rock, Litho		Seal, Chrono		Seal, Litho		
Callovian - Oxfordian	Viking Gp: Heather Fm		Toarcian		Dunlin Gp: Drake Fm		
Seismic database (2D/3D):		BG0806 (2008 3D survey with PSDM processing)					
Probability of discovery:							
Technical (oil+gas case)		0.12		Prob for oil/gas case		oil case unlikely	
Probability (fraction):		Reservoir (P1)	Trap (P2)	Charge (P3)	Retention (P4)		
		0.4	1	0.5	0.6		
Parameters		Low	Base	High	Comments		
Depth to top of prospect (m)		4225	4175	4125			
Area of closure (km2)		3.6	10.4	20.9			
Reservoir thickness (m)		122	122	122	Narrow range constrained by 35/4-1 well		
HC column in prospect (m)		90	140	190	Constrained by WUT in 35/4-1 well		
Gross rock vol. (109 m3)		90	380	1400	Wide range due to uncertainty re degree of fill above the WUT in 35/4-1 well		
Net / Gross (fraction)		0.28	0.32	0.36			
Porosity (fraction)		0.13	0.14	0.15	Narrow range constrained by 35/4-1 well		
Water Saturation (fraction)		0.38	0.35	0.32			
Bg. (<1)		0.0033	0.0031	0.0028			
Bo. (>1)							
GOR, free gas (Sm3 /Sm3)							
GOR, oil (Sm3 /Sm3)							
Recovery factor, main phase		0.57	0.65	0.73			
Recovery factor, ass. phase		0.35	0.4	0.45	Condensate		
Temperature, top res (deg C):		145	Pressure, top res (bar) :		793		

Fig. 4.1 Boysenbær North Prospect Summary Sheet

Block	Prospect Name		Discovery / Prospect / Lead		Prosp ID (or new)	NPD approved
35/7 & 35/8 (only 50% of the prospect lies in PL467S)	Boysenbær South		Prospect		NPD will insert data	NPD will insert data
Play (name/new)	Structural element		Company / reported by / Ref doc.			Year
NPD will insert data	Tampen Spur		BG Norge AS			2012
Gas condensate case	Resources IN Place					
	Main phase			Ass. Phase		
	Low	Mid	High	Low	Mid	High
Condensate 106 Sm3				6.99	10.6	14.3
Gas 109 Sm3	12.4	14.7	17.1			
	Resources RECOVERABLE					
	Main phase			Ass. Phase		
	Low	Mid	High	Low	Mid	High
Condensate 106 Sm3				2.74	4.23	5.8
Gas 109 Sm3	7.73	9.53	11.4			
	Which fractiles are used as:		Low	P90	High	P10
Type of Trap	Water Depth (m)		Reservoir Chrono (from - to)		Reservoir Litho (from - to)	
Dip / fault closed	380		Late Pliensbachian - Toarcian		Dunlin Gp: Cook Fm	
Source Rock, Chrono	Source Rock, Litho		Seal, Chrono		Seal, Litho	
Callovian - Oxfordian	Viking Gp: Heather Fm		Toarcian		Dunlin Gp: Drake Fm	
Seismic database (2D/3D):		BG0806 (2008 3D survey with PSDM processing)				
Probability of discovery:						
Technical (oil+gas case)		0.06		Prob for oil/gas case		oil case unlikely
Probability (fraction):		Reservoir (P1)	Trap (P2)	Charge (P3)	Retention (P4)	
		0.32	0.8	0.4	0.6	
Parameters		Low	Base	High	Comments	
Depth to top of prospect (m)		4340	4240	4140		
Area of closure (km2)		22	22	22		
Reservoir thickness (m)		122	122	122	Narrow range constrained by 35/4-1 well	
HC column in prospect (m)		350	350	350	Modelled as full to spill. Partial fill is a possible alternative model	
Gross rock vol. (109 m3)		1714.9	1714.9	1714.9		
Net / Gross (fraction)		0.279	0.32	0.361		
Porosity (fraction)		0.13	0.14	0.15	Narrow range constrained by 35/4-1 well	
Water Saturation (fraction)		0.38	0.35	0.32		
Bg. (<1)		0.0033	0.0031	0.0028		
Bo. (>1)						
GOR, free gas (Sm3 /Sm3)						
GOR, oil (Sm3 /Sm3)						
Recovery factor, main phase		0.57	0.65	0.73		
Recovery factor, ass. phase		0.35	0.4	0.45	Condensate	
Temperature, top res (deg C):		145	Pressure, top res (bar) :		793	

Fig. 4.2 Boysenbær South Prospect Summary Sheet

5 Conclusions

The PL467S partners decided to relinquish the licence following the acquisition and interpretation of new 3D seismic that showed that the Boysenbær prospect is split in to two separate segments and that the Northern segment has already been drilled by well 35/4-1. The remaining prospects have significantly smaller combined volumes and higher risks, compared to the interpretation at the time of licence application.

