



# Relinquishment Report

# PL412

Blocks  
25/5, 6, 8 & 9



VNG Norge



## List of figures

4.1	License inventory map from APA 2006.....	5
4.2	Updated license inventory map .....	6

## List of tables

3.1	Studies carried out on the common well database .....	3
4.1	PL412 license inventory .....	7

## 1 License history

Production license (PL) 412 includes parts of blocks 25/5, 25/6, 25/8 and 25/9. The license was awarded to Norwegian Energy Company ASA (Noreco) as Operator with 40% interest, Lundin Norway AS (30%) and Endeavour Energy AS (30%) on February 16<sup>th</sup> 2007 as part of the awards in predefined areas (APA) 2006. The license was active for 4 years and a total of 12 partner meetings were held during this period.

- 28th March 2007 (EC/MC No. 1)
- 17th October 2007 (Workshop)
- 14th November 2007 (EC/MC No. 2)
- 26th June 2008 (EC/MC No. 3)
- 29th April 2008 (EC Work Meeting)
- 15th October 2008 (EC/MC No. 4)
- 7th January 2009 (Drilling Programme Peer Review and Risk Assessment)
- 28th April 2009 (EC Work Meeting)
- 24th November 2009 (EC/MC No. 5)
- 3rd June 2010 (EC/MC No. 6)
- 22nd September 2010 (EC Work Meeting)
- 18th November 2010 (EC/MC No. 7)

The first phase of the work obligation, which had to be fulfilled within 4 years from award, included the following:

- To obtain and reprocess a minimum of 200 square km of seismic reflection data over the production license acreage.
- To drill two exploration wells, one being mandatory.
- To make a decision about forwarding a plan for development (in Norwegian 'Beslutning om Videreføring', BoV).

The seismic part of the work obligation was fulfilled in 2007 when three seismic surveys (approx. 1540 sq.km) were reprocessed and merged.

Two prospects and six leads were identified before the license was awarded. The two prospects were 'Eiganes' with reservoir in the Paleocene Ty Formation and 'Tasta' with reservoir in the middle Jurassic Vestland Group. Both these prospects were drilled and found to be dry in 2009. The Eiganes Prospect, which extended into the neighbouring PL027D, was drilled in an optimal position by well 25/8-16S (in PL027D) whereas the Tasta Prospect was drilled by well 25/9-3 (in PL412).

Technical evaluations carried out after the drilling of wells 26/8-16 in PL027D and 25/9-3 in PL412 indicated that the remaining opportunities within PL412 were sub economic and/or had very low chances of success. Consequently the license group decided to apply for exemption from drilling a second exploration well in PL412. The application for exempt (Noreco reference HB#51733, OD reference no. 10/974) was filed and accepted by OED in Q4 2010.

As the license group decided *not* to submit a 'BoV', the Production license became inactive according to the Joint Operational Agreement from 17. February 2011.

## 2 Database

The original common well database included 19 wells but was extended to also include well 25/8-16S (which was drilled in the adjacent production license 027D in 2009) and the PL412 well 25/9-3 'Tasta'. The well data that have been used for technical analyses include petrophysical logs and borehole samples such as core, cuttings and oils. A list of the wells used and the studies carried out is provided in the next chapter (*see* Table 3.1).

The seismic database consisted originally of the 3D surveys ES9403, ST9707 and UHN98 (south of 25/3 block boundary). These surveys were reprocessed and integrated into a singular merged cube named NO0701 (CGGVeritas, 2007) which was later noise cancelled and spectrally enhanced to produce a clean well imaged data set, consistent across the whole area (ffa, 2008). The 3D cube EL9201 was later added to the database in order to fully cover the part of block 25/5 that was inside PL412. This cube was noise cancelled and spectrally enhanced inhouse by Noreco.

Two rig site surveys were performed in the PL412 area to cover potential well locations and relief well locations on the Eiganes and Tasta Prospects (Gardline, 2008, I and II).

## 3 Review of geological framework

The key plays in the area that were considered for APA 2006 were:

- Paleocene gravity flows of the Ty Fm
- Middle Jurassic Hugin Fm
- Lower Jurassic Statfjord Fm

Of these plays, the Paleocene gravity flow deposits of the Ty Fm were believed to have the highest petroleum potential. It was demonstrated that the Ty Fm pinches out along the north and west flanks of the Utsira High and it was thus believed that the pinch out could form a stratigraphic trap for the Eiganes Prospect. Although this play was proven with the Ringhorne West discovery in block 25/8, trap definition was considered to be the main risk of the Eiganes Prospect.

The shallow marine Hugin Fm shoreface unit was considered to be eroded and sub-crop along the northern flank of the Utsira High. The Tasta Prospect was identified in this play with the main risk being trap definition.

The 25/6-1 discovery in the Hugin Fm was believed to represent attractive volumes given more discoveries were made nearby. Little or no potential was seen in the 25/8-9 discovery due to very poor reservoir development in the Heimdal Fm and a small structural closure.

Several studies were performed in order to address the key geological uncertainties associated with the discoveries, prospects and leads presented in the original application document (APA, 2006). These studies were also used in the exploration for new opportunities in the license area.

The work on the well data included (1) comprehensive top-to-bottom log data conditioning followed by computer processed interpretations, generation of synthetic seismograms and modelling of rock and fluid properties (RSI, 2007); (2) sedimentological description and facies interpretation of borehole cores combined with statistical analysis of reservoir quality from conventional core data (Noreco, 2007); (3) biostratigraphic analysis based on reports and/or raw data (APT, 2007); (4) processing and interpretation of image and dip meter logs (Ichron, 2007); and (5) a sequence stratigraphic study based on all available biostratigraphy reports, petrophysical log correlations and

interpretation of seismic reflection data (Geolink, 2007). A geochemical study of DST and wire-line samples of some 30 oils from 20 wells was also carried out (APT, 2008).

Table 3.1

*Table 3.1 Studies carried out on the common well database. The crosses in this table specify the wells included in studies 1 to 5 described in the text.*

Well	(1) Rock physics	(2) Wellbore core	(3) Biostratigraphy	(4) Image log study	(5) Seq.Strat.
25/5-1	x	x			x
25/5-1A					
25/5-2	x	x			x
25/5-3	x	x	x		x
25/6-1	x	x			x
25/6-2	x		x		x
25/6-3	x		x		
25/8-2	x				x
25/8-7	x	x		x	x
25/8-8A					
25/8-8B					
25/8-8S	x		x		x
25/8-9	x	x		x	x
25/8-9A					
25/8-11	x		x		x
25/8-13	x		x		x
25/8-16S					
25/9-1	x	x		x	x
25/9-2S			x		x
25/9-3					
26/4-1	x	x			x

Ref.: -NOR--60528

The work on the seismic data set included reprocessing and merging of 3D cubes (CGGVeritas, 2007), noise cancellation, spectral enhancement, spectral decomposition, generation of facies classification cubes, attribute analysis and extraction of geobodies. The reprocessed, noise cancelled and spectrally enhanced seismic reflection data was used for structural interpretation tied to wells. Mapping on the reprocessed, merged and conditioned dataset confirmed the prospectivity outlined in the original application document.

A primary objective of the technical evaluations was to address the uncertainties associated with the traps of the two main prospects presented in the original application document (APA, 2006). Both these prospects (i.e. the Eiganes Prospect with Paleocene Ty Fm reservoir and the Tasta Prospect with Jurassic Vestland Gp reservoir) were dependent on a stratigraphic trap component. The possible pinch outs of these reservoirs were therefore located using geophysical techniques designed to facilitate more detailed and confident reservoir mapping. Geological/statistical techniques for estimation of reservoir thickness were used in areas where the reservoirs were too thin to be accurately assessed by means of seismic reflection data. This resulted in revised top reservoir maps and verification of a 'pinch-out potential' in the Eiganes and Tasta prospects.

The Ty Fm Eiganes Prospect was drilled in 2009. The well (25/8-16S) encountered good reservoir with no shows in the Ty Fm and a thin oil bearing reservoir layer in the overlying Heimdal Fm. The most important change in the understanding of the geological framework that resulted from the post well evaluations was the recognition of likely sand injectites that connect the Ty Fm with the Heimdal Fm. This recognition had implications for the evaluation of trap efficiency as well as the understanding of the migration of hydrocarbons in Palaeocene strata, as further addressed in Chapter 4.

The Vestland Gp Tasta Prospect was drilled later the same year. The well was dry but came in largely according to the geological prognosis. Traces of migrated hydrocarbons had earlier been identified directly above the Hugin reservoir in the nearby well 25/9-1 (Amerada Hess, 1995) but further studies of core extracts suggested a rather immature signature over this interval (APT, 2007 I).

Moreover, a post well fluid inclusion study carried out on cuttings from the Tasta well and well 25/9-1 (FIT, 2010 I and II) did not result in identification of liquid hydrocarbons in or near the Hugin reservoir in any of the two wells, but minor intermittent dry gas responses were noted some places in both wells. Evidence to support efficient migration of hydrocarbons from a mature source rock in the Viking Graben area to the Tasta Prospect has thus not been found. It is therefore unclear whether the dry well result was due to lack of migration or trap.

The last key play presented in the application document (APA, 2006), namely the Lower Jurassic Statfjord Fm, was also thoroughly studied. This resulted in definition of a new prospect (the Midjord Prospec, *see* 4 Prospect update) which was regarded to be too small to justify drilling and associated with significant uncertainty with respect to hydrocarbon migration.

## 4 Prospect update

Most of the prospects and leads in the PL412 area were identified prior to the Application in Predefined Areas (APA) 2006 (compare Fig. 4.1 and Fig. 4.2). The two main prospects presented in the original application document were the Paleocene 'Eiganes' with reservoir in the Ty Formation and the Middle Jurassic 'Tasta' with reservoir in the Hugin and Bryne Formations. The Tasta Prospect was drilled by the PL412 group in 2009 whereas the Eiganes Prospect was drilled the same year in the adjacent PL027D. Both these prospects were found to be dry. All remaining opportunities in the license were revisited and exploration for new opportunities was carried out but did not result in identification of prospectivity of economic interest. The updated license inventory is summarised in Table 4.1 below.

### The Eiganes Prospect

The Eiganes prospect was the highest ranked opportunity presented in the original application document. The prospect was targeted in an optimal position by well 25/8-16S (Eitri). Oil was encountered in poor reservoir facies in the Heimdal Fm but the Ty Fm (i.e. the Eiganes prospect) was proven to be dry. The remaining untested potential in a separate closure in PL412 was re-assessed based on the result of this well and the learning from the abovementioned subsurface work. Recognition of petrophysically 'masked' glauconitic sandstones in core and cuttings from Heimdal formation in well 25/8-7 suggested that this interval is more sandy and has therefore lower potential in terms of sealing capacity than earlier anticipated. The recognition of a higher sand content in combination with very high angle dip meter readings (60dg +) and common high-angle seismic reflectors within the Heimdal and Ty formations further indicated the presence of sand injectites in several places above the Eiganes Prospect. Such sand injectites are likely to connect the Ty and Heimdal Fms and would thus explain the accumulation of hydrocarbons exclusively in the Heimdal Fm in well 25/8-16S and also the reported weak shows in the Heimdal Fm in wells 25/8-7 and 25/9-1. Any hydrocarbons that may have migrated in the Ty Fm could have leaked to the Heimdal Fm before reaching the Eiganes Prospect or, alternatively, leaked near the top of the Eiganes structures where high-angle seismic reflectors indicative of injectites have been mapped. The recognition of likely injectites in the Ty and Heimdal Fms has therefore added significant risk to both migration and trapping of hydrocarbons in the Eiganes Prospect.

The reservoir quality and connectivity within the Heimdal Fm is believed to decay rapidly east of the Jotun Field. This hypothesis was validated by the results of wells 25/8-16S and 25/8-17 (Jetta) that both discovered hydrocarbons in thin Heimdal Fm reservoir layers encased in non-reservoir rocks. The PL412 area, which is located even further to the east, is positioned in an even more distal portion

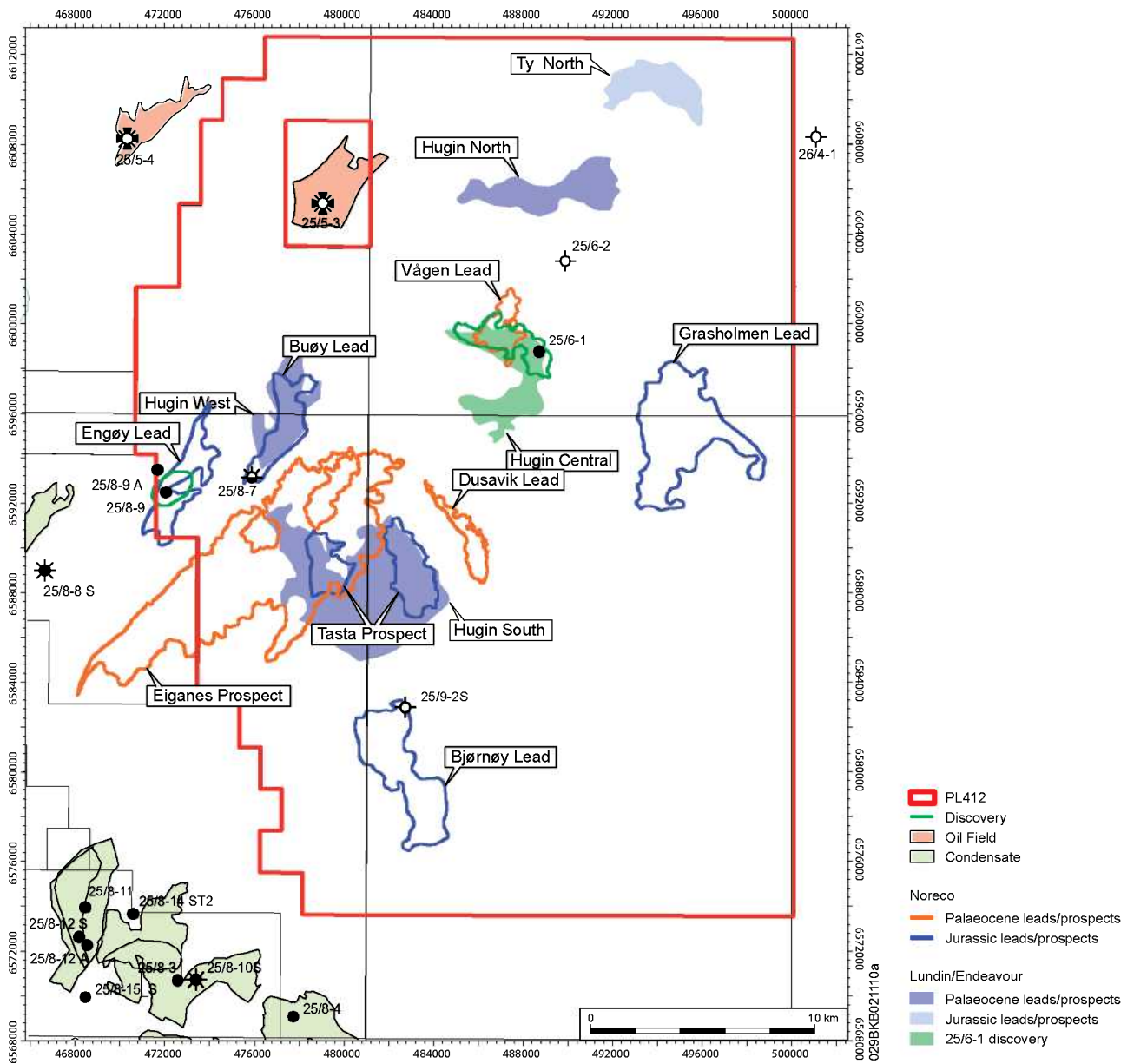


Fig. 4.1 License inventory map from APA 2006



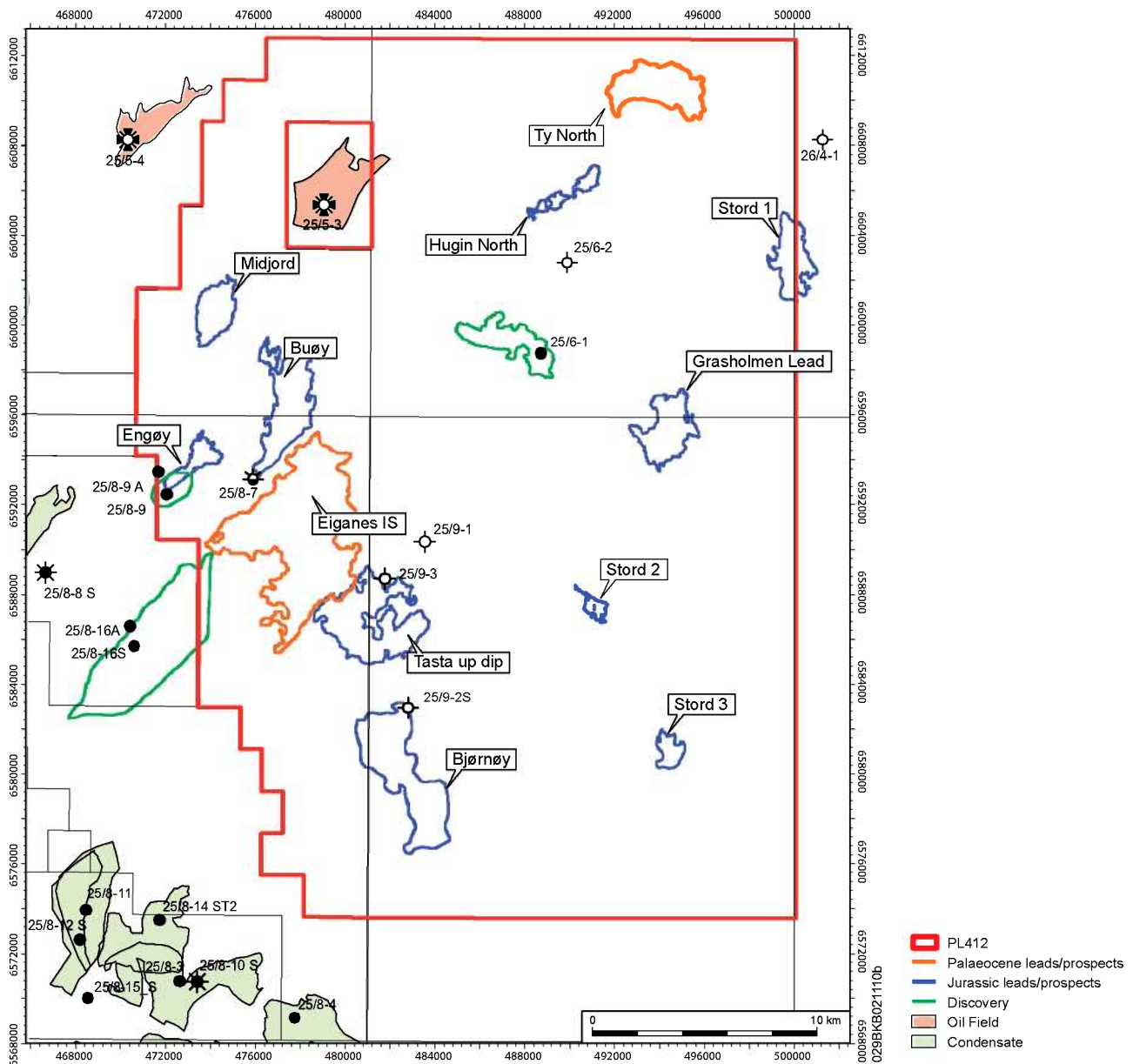


Fig. 4.2 Updated license inventory map

of the Heimdal submarine fan and thorough seismic mapping along with amplitude studies has not reveal any evidence to support presence of favourable Heimdal Fm reservoir in this area. An economic hydrocarbon accumulation in the Heimdal Fm above the Eignaes Prospect is therefore regarded as unlikely.

### The Tasta Prospect

The Tasta prospect was tested by well 25/9-3. The geological results of the well came in as prognosed. The Vestland Gp reservoir had a gross thickness of approximately 10 m containing two sandstone units separated by a 2 m thick coal/shale layer in the middle. Both sandstone sequences had good reservoir properties, but no indications of hydrocarbons were found (Noreco, 2010). The lack of hydrocarbons may be explained by no migration or lack of a functional trap. Conclusive evidence in favour of one or another of these two explanations has not been found but the subsurface work carried out prior to drilling indicated that the most likely failure mechanism would be an inefficient trap. Post well analysis indicated that the up dip untested potential in the Tasta structure is sub economical and associated with significant risk.

### The Midjord Prospect

The Midjord Prospect was identified after the license was awarded. The main reservoir is the Statfjord Fm and the trap is a Jurassic horst block with dip closure towards north and upside fault closure in the other directions. The trap is well defined on seismic reflection data and the gross rock volume of the reservoir under closure is limited by the rather small size of the distinct structure. There is therefore little upside volume potential, and the reserves are not regarded to be of economic interest. There is also considerable uncertainty and risk associated with hydrocarbon migration in the Statfjord Fm in this area.

### Other opportunities

The remaining leads presented in APA 2006 have been evaluated and updated as shown in Table 4.1. Seismic anomalies indicative of shallow gas were also explored but these likely hydrocarbon accumulations appear to be distributed in rather small 'pockets' and an economic potential could therefore not be validated for the PL412 area.

*Table 4.1 PL412 license inventory. Abbreviation IS = Independant Structure. Refers to the part of the Eiganes prospect that was not tested by well 25/8-16S.*

Name	Formation	Status	Recoverable resources Sm3			COS (%)
			P90	P50	P10	
25/6-1	Hugin	Discovery	0,38	1,21	2,13	
25/8-9	Heimdal	Discovery		0,80		
Eiganes IS	Ty	Prospect	3	4,60	7	8
Midjord	Statfjord	Prospect	1,33	1,86	2,4	36
Hugin North	Hugin	Prospect	0,15	0,27	0,47	72
Tasta Updip	Hugin	Prospect	0,36	0,62	1,1	8
Ty North	Ty	Lead		11,4		
Grasholmen	Hugin+Statfjord	Lead		4,7		
Stord 1	Hugin	Lead		0,9		
Stord 2	Hugin	Lead		0,15		
Stord 3	Hugin	Lead		0,3		
Bjørnøy	Statfjord	Lead		4,60		
Engøy	Statfjord	Lead		5,2		
Buøy	Hugin	Lead		5,2		

Ref.: -NOR--49663

## 5 Technical evaluations

Technical evaluations were performed regarding the possible development of a discovery on the Eiganes or Tasta prospect. A scenario with subsea development of the 25/6-1 discovery together with Eiganes and Tasta was also evaluated. However, the technical evaluations suggested that an economic viable development would rely on a discovery on either Tasta or Eiganes. The remaining license portfolio after negative well results on both these prospects Table 4.1 is therefore regarded as uneconomic or associated with unacceptable risk.

## 6 Conclusions

The Eiganes Prospect was considered in APA 2006 to have the highest petroleum potential. The high potential of this prospect relied on a Ty Fm stratigraphic trap on the western side of the Utsira high. However, the prospect was tested by well 25/8-16S and found to be dry. Post well analysis suggests that the most likely reason for failure is the presence of sand injectites that connect the Ty Fm with thin permeable layers in the overlying Heimdal Fm. The trap risk associated with remaining prospectivity in the Ty Fm in the parts of PL412 where distal thin stringers of the Heimdal Fm overlies the Ty Fm is therefore extremely high. There is also a high risk that any hydrocarbons that may have been charged into the Ty Fm leaked to the Heimdal Fm before reaching a potential trap in the Ty Fm. The Ty Fm pinch-out trap play model has therefore not been further explored.

Paleocene gravity flows of the Heimdal Fm has earlier been tested by well 25/8-9 (1995) which found thin and laterally discontinuous oil-bearing reservoirs in a small 4-way dip closure near the top of the Heimdal Fm. The presence of hydrocarbons in 4-way dip closure with poor reservoir quality was also demonstrated by well 25/8-16S. No economic potential is expected in the Heimdal Fm in PL412 due to poor reservoir quality.

A sub-economic hydrocarbon accumulation in the Hugin Fm was discovered by well 25/6-1 in 1996. The 25/6-1 discovery could have provided attractive volumes if more discoveries were made close by. However, well 25/9-3 drilled the Hugin reservoir in the near by Tasta Prospect without encountering any hydrocarbons.

The wells that drilled the Eiganes and Tasta prospects did not test the entire potential of these two traps; The Tasta well was *not* drilled in the most crestal position of the structure and some updip potential is therefore still present. Likewise, a possible separate stratigraphic closure within the Eiganes Prospect remains untested. The remaining potential in these two prospects is associated with very high risk due to the negative well results. There is also some high-risk untested potential in the Statfjord Fm. However, an economic viable development scenario for the remaining opportunities in the license area (*cf.* Table 4.1 and Fig. 4.2) has not been found.

The license was relinquished because the technical evaluations after the initial period indicated that the hydrocarbon potential in the license area was sub economic and/or associated with unacceptable risk. The Operator and licensees were therefore aligned on not submitting a 'BOV', and consequently the license became inactive from the 17th of February 2011 according to the Joint Operational Agreement .

## 7 References

- APA (2006) - Geological and technological evaluation- Block 25/6, 25/8 and 25/8-9. In: Application in Predifined Areas 2006. Noreco ref. HB#24906. Norwegian Energy Company, Stavanger, Norway, pp. 12-44 plus figures.
- APT (2007, I) - Petroleum Geochemistry Systems of PL412. Volume 1: Text and Figures. Noreco ref. HB#61869. Applied Petroleum Technology AS, Kjeller, Norway. 30 pp.
- APT (2007, II) - Petroleum Geochemistry Systems of PL412. Volume 2: Geochemical Data Report. Noreco ref. HB#61868. Applied Petroleum Technology AS, Kjeller, Norway. 303 pp.
- CGG Veritas (2007) - Processing Report, NO07M01 merged 3D-survey, Norwegian North Sea, Quad 25, PL412. Noreco ref. HB#61872. CGG Veritas, Norway, 81 pp.

**FIT (2010 I)** -A Stratigraphic Reconstruction of Bulk Volatile Chemistry from Fluid Inclusions in well 25/9-3. FIT ref.: FI100943b, Noreco ref. HB#53668. Fluid Inclusion Technologies Inc., Oklahoma, USA, 76 pp.

**FIT (2010 II)** -A Stratigraphic Reconstruction of Bulk Volatile Chemistry from Fluid Inclusions in well 25/9-1. FIT ref.: FI100943a, Noreco ref. HB#53670. Fluid Inclusion Technologies Inc., Oklahoma, USA, 76 pp.

**ffa (2008)** - Noise Cancellation & Spectral Whitening, Norwegian North Sea, Noreco (Norwegian Energy Company AS) NOR01\_10/07. Noreco ref. HB#18408. Foster Findlay Associates Ltd., Aberdeen, United Kingdom, 14 pp.

**Gardline (2008 I)** - Survey Report, NCS 25/9 Eiganes Rig Site Survey. Gardline ref. 7760.1, Noreco ref. HB#62050. Gardline, Norfolk, United Kingdom, 241 pp.

**Gardline (2008 II)** - Survey Report, NCS 25/9 Tasta Rig Site Survey. Gardline ref. 7761, Noreco ref. HB#62052. Gardline, Norfolk, United Kingdom, 214 pp.

**Geolink (2007 I)** - PL412 Sequence Stratigraphy Study, Vestland Group. Noreco ref. HB#61995. Geolink, Meyland, France.

**Geolink (2007 II)** - PL412 Sequence Stratigraphy Study, Paleocene- Eocene Succession. Noreco ref. HB#61996. Geolink, Meyland, France.

**Ichron (2007)** - Image log and dipmeter interpretation of the Hugin and Tarbet Formations, wells 25/8-7, 25/8-9 and 25/9-1, PL412, NOCS. Ichron ref. #07\_1167\_S, Noreco ref. HB#7986. Ichron Lmtd., Northwich Cheshire, United Kingdom, 15 pp.

**Noreco (2007)** - Sedimentological core descriptions, Northern Utsira High. Noreco ref. HB#36879. Norwegian Energy Company ASA, Norway, 9 pp.

**Noreco (2010)** - 25/9-3, Final Well Report. Noreco ref. HB#41664. Norwegian Energy Company ASA, Norway, 72 pp.

**RSI (2007)** - Rock Physics and Seismic Atlas, NCS Blocks 25, 26, Geophysical Well Log Analysis and Synthetic Seismic Analysis. Noreco ref. HB#61861. Rock Solid Images AS, Oslo, Norway. 17pp.