



## **PL 457 Surrender Report**

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## 1 Key License History

Production License 457 was awarded to Revus Energy ASA (operator 40%), Endeavour Energy Norge AS AS (20%), Bridge Energy AS (20%) and E.ON Ruhrgas (20%) after the APA 2007, and became effective on 29<sup>th</sup> February 2008. The license is situated in block 16/1 in the North Sea covering a total of 53,436 km<sup>2</sup>. At the time of surrender the licensees are Wintershall Norge AS (operator 40%), Aker BP (40%) and VNG Norge AS (20%). The work commitment of the license included G&G studies and reprocessing seismic data. (Fig. 1.1)

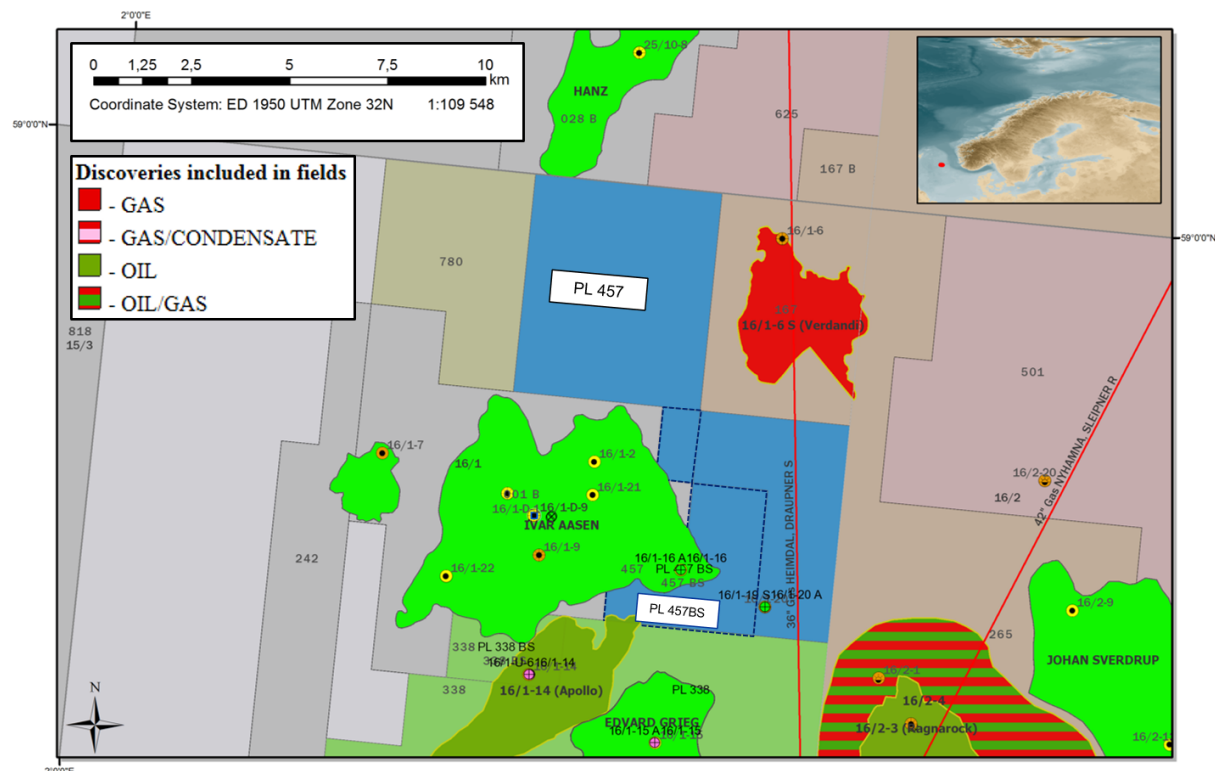


Fig. 1.1 Location of PL 457 & PL 457BS

The commitment was fulfilled with reprocessing of the 3D surveys ES9402, ST9511 and UH3D95 in 2008/2009 carried out by WesternGeco (WesternGeco 2009). The output dataset, ES9402MR08, comprises an area of about 950 km<sup>2</sup>. See 2 Database

The initial license period started on 29<sup>th</sup> February 2008 and ended on 1<sup>st</sup> March 2015. During that period three exploration wells and one appraisal well were drilled and completed. In 2012, exploration well 16/1-16 and the appraisal sidetrack 16/1-16A successfully tested oil in the Middle Jurassic Hugin FM and the Skagerak FM sandstone of the "Asha" prospect, an eastern extension of the Ivar Aasen field. The stratigraphical levels between base upper Jurassic and 100 meter below base Jurassic reservoir level of the "Asha" area were carved out of PL457 in 2015 and included in the Ivar Aasen field development, resulting in Production License 457BS covering an area of 12.479 km<sup>2</sup>. Two further exploration wells were drilled and completed in 2013. Both wells 16/1-19S, aiming for the weathered Basement prospect "Amol" as well as well 16/1-20A, aiming for the Late Jurassic "Asha-East" prospect, were found dry. In March 2015 the initial phase was extended by the Ministry of Petroleum and Energy (MPE) until 28<sup>th</sup> February 2018 with a Drill or Drop decision due on 1<sup>st</sup> March 2016. The date for the Drill or Drop decision was then extended to 1<sup>st</sup> March 2017. The remaining potential of PL 457 was evaluated according to the work commitment. Several leads in the licenses were identified, but were either too small and/or high risk for any further appraisal activity and development and hence an unanimous full license surrender decision was taken within the JV.

The largest remaining prospects in PL457 are the Paleocene Heimdal Formation "Goldfish" prospect and the Eocene Grid Formation "Aglaja" prospect. "Goldfish" is a hanging wall 3-way dip closure with mean recoverable resources of 2,2 MMm<sup>3</sup> o.e. and a GPOS of 17%. Only 0,5 MMm<sup>3</sup> o.e. of the recoverable resources are located within the PL457 license area. The main risk, leakage through the eastern bounding fault could not be mitigated during the process of evaluation. "Aglaja" is a high seismic amplitude feature, which was in the original license application (2008) supposed to represent a high porosity sand injectite enclosed by shales, analogue to the reservoir of the Volund field about 70 km Northwest of PL457. The prospect was then downgraded by intensive geophysical studies, which came to the conclusion that the high amplitudes are caused by cementation. The prospect is now estimated to contain 1 MMm<sup>3</sup> o.e. of mean recoverable resources with a GPOS of 14%. See 4 Prospect Update report

All identified license prospects and leads are considered as being non-commercial at the time being. Therefore the unanimous decision for a full license surrender of PL457 within the joint venture was taken.

## 2 Database

### 2.1 Seismic data

As part of the work commitment in PL457, seismic reprocessing of the 3D surveys ES9402, ST9511 and UH3D95 was carried out in 2008/2009 by WesternGeco. The output dataset, ES9402MR08, comprises an area of about 950 km<sup>2</sup>.

In 2009 the PGS Geostreamer 3D survey LN0902 (1770 km<sup>2</sup>) was purchased and reprocessed by PGS in 2010 in the Ivar Aasen / PL457 area (417 km<sup>2</sup>).

In 2012 the broadband 3D seismic surveys LN12002 and LN11004, acquired by CGG were purchased, merged (2810 km<sup>2</sup>) and processed. A reprocessing in 2014 was accomplished as part of the work program for the second license period.

In addition the regional PGS MegaMerge 3D seismic survey, as well as the OBC 3D seismic survey over Ivar Aasen, DN1302 (70 km<sup>2</sup>), were used for interpretation. Fig. 2.1, Fig. 2.2

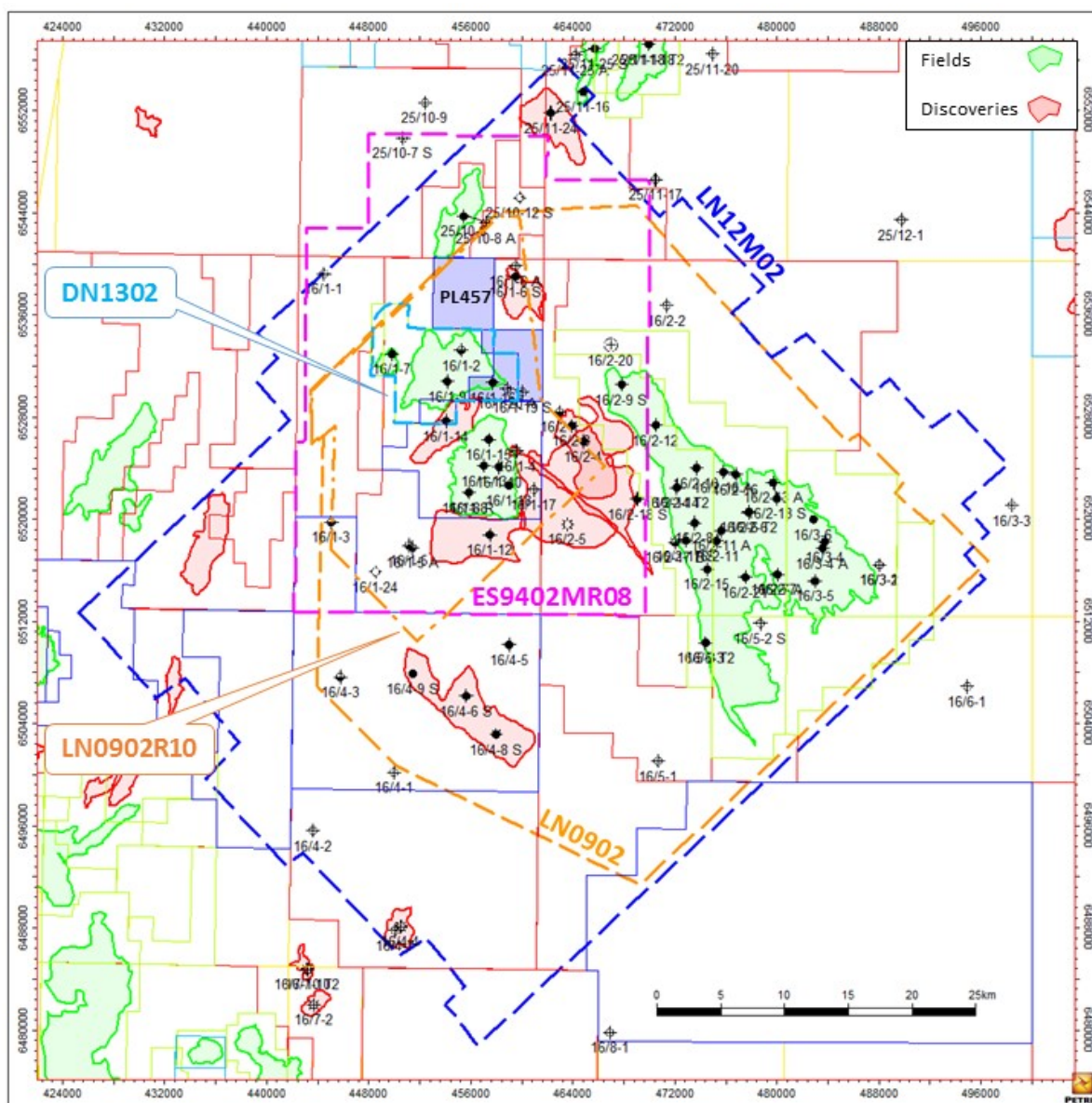


Fig. 2.1 3D Seismic Database



3D seismic dataset	Survey 1	NPDID	Category	Survey 2	NPDID	Category	Survey 3	NPDID	Category
ES9402MR08	E59402	3643	License owned	ST9511	3742	License owned	UH3D95	3745	License owned
LN0902	LN0902	7004	License owned						
LN0902R10	LN0902	7004	License owned						
LN12M02	LN11004	7525	License owned	LN12002	7618	License owned			
LN12M02R14	LN11004	7525	License owned	LN12002	7618	License owned			
DN1302 (FT)	DN1302	7852	License owned						
MEGAMERGE (PGS)			Market available						

Fig. 2.2 Database PL 457 - 3D Seismic data

## 2.2 Well data

The well database consists of the wells in and adjacent to PL457 as well as some reference wells in the Balder, Svalin and Volund fields.

Wells 16/1-16, 16/1-16A, 16/1-19S and 16/1-20A were drilled in 2012/2013 during the initial license period. Fig. 2.3

Well	NPDID	Well	NPDID	Well	NPDID	Well	NPDID
16/1-1	147	16/1-11	6157	16/1-21A	7530	25/10-8	2955
16/1-2	332	16/1-11A	6364	16/1-22S	7531	25/10-8A	3098
16/1-4	2072	16/1-14	6399	16/1-22A	7716	25/10-12 S	7293
16/1-5	3279	16/1-15	6517	16/1-22B	7720	25/10-12 ST2	7293
16/1-6S	4711	16/1-16	6823	16/2-1	144	25/11-7	368
16/1-6A	4767	16/1-16A	7095	24/9-7A	4919	25/11-8	369
16/1-7	4928	16/1-19S	7255	24/9-7B	4926	25/11-16	1920
16/1-8	5612	16/1-20A	7256	24/9-7C	4930	25/11-24	5470
16/1-9	5773	16/1-21S	7529	25/10-7S	2769	25/11-28	7776

Fig. 2.3 Database PL 457 - Well data

## 2.3 Special studies

In addition to seismic interpretation, inversion, AVO analysis, fault seal analysis, log evaluation, petrography and petroleum system analysis, a number of external special geological and geochemical studies were carried out in order to evaluate the hydrocarbon potential of the license. Fig. 2.4

Company/Author	Title	Year
ICHRON	Integrated stratigraphic and depositional model for the Middle to Upper Jurassic succession of the South Viking Graben, PL457 area	2010
ICHRON	Petrographic study of core and cuttings samples from the Grid Sandstone Member, Blocks 16/1 and 25/10, South Viking Graben, PL457 Area	2010
ICHRON	South Viking Graben and Utsira High Stratigraphic Database - 2014 Version	2012
APT	Geochemistry Data Report - Wells 16 1-16 and 16 1-16 A	2013
ICHRON	A Biostratigraphic Evaluation of Well 16/1-19S (Amol Prospect), NOCS	2014
ICHRON	Biostratigraphic evaluation and core description of wells within the Ivar Aasen/Asha area, NOCS	2014
ICHRON	A Biostratigraphic Evaluation of Well 16/1-20AT3, Asha East, NOCS	2014
T. Pakenham	Cross-disciplinary porosity determination of sand bodies from seismic amplitudes and thin sections (Thesis University of Aberdeen)	2015
FIT	A Stratigraphic Reconstruction of Bulk Volatile Chemistry from Fluid Inclusions in 25/10-8	2016
APT	Geochemistry Data Report - Analysis of 1 DST Oil Sample from Well 25/10-8	2016

Fig. 2.4 PL457 Database - Special Studies

### 3 Review of Geological and Geophysical studies

Several geological and geophysical studies were performed in the area of PL457. The stratigraphical framework was defined by a regional stratigraphic study of wells in the South Viking Graben and Utsira High in 2012 and then updated by stratigraphic studies for the recently drilled wells in PL 457. Main structural elements in the study area are the southern Viking Graben and the northwestern slope of the Utsira Basement High. The Utsira High was exposed several times from the Permian to the Cretaceous Albian – Aptian. It consists of a basement horst structure with prominent, sediment filled valley systems in excess of 400 m thick on top. In the graben area adjacent to the west, Permian clastics and carbonates as well as Triassic and Jurassic clastics were deposited. Large scale extension and subsequent fault block rotation occurred during the Late Jurassic. A significant uplift at Base Volgian time resulted in a new major erosion and a rapid deposition of an "immature" transgressive sand sequence with high porosity and extremely good permeability around the Utsira High. The Volgian transgression was followed by the deposition of fault escarpment delta fans during the Early Cretaceous west and east of the Utsira High. After subsidence, Late Cretaceous limestones were deposited and partly eroded during a new significant uplift of the Utsira block in the Early Paleocene. In PL457 the limestones directly overlie the Lower Cretaceous sandstone and therefore no retention for hydrocarbons is provided. A rapid subsidence of the exposed area occurred during Paleocene time, followed by the deposition of deep marine fan systems comprising the Ty FM and Heimdal FM sediments. The Heimdal FM is supposed to be derived from the Shetland Platform west of the Viking Graben. The whole Tertiary succession consists of a conformably stacked marine sandstone – shale section. Detached deformation can be observed within the shales of the Skade group as a response to recent rifting movements.

The main oil reservoirs are shallow marine and nearshore Middle Jurassic sandstones, fringing the Utsira High provenance area. A sedimentological study interpreted the sands in well 16/1-16 as fluvial channel fill (Sleipner FM) and part of a pro-grading delta front (Hugin FM). The predominant type of structural hydrocarbon trap for that level are hanging wall 3-way dip closures with a high risk of leakage at the bounding faults, as proven by well 16/1-20A.

Reservoirs prognosed effective in the Lower Cretaceous section as well as the weathered basement had to be downgraded after drilling of wells 16/1-19S and 16/1-16. The prospects on these levels (Noor, Amol prospects) were mainly defined by seismic amplitude anomalies but turned out to be dry.

The Goldfish prospect (Paleocene Heimdal FM, Fig. 4.4) reservoir sand was investigated by several studies. The prospect configuration is a hanging wall 3-way dip closure with leakage through the eastern bounding fault as the main risk. This risk could neither be mitigated by a petrography study in 2016, aiming to prove different provenance areas for hanging and footwall, nor by a fault seal analysis and an AVO study.

The prospect Aglaja, included in the original license application 2007 is a high amplitude features within the Eocene/Oligocene seismic package. It was originally interpreted as an analogue to the Volund field injectite reservoir, with good poroperm parameters. A petrography study for the Eocene Grid sandstone in 2010 came to the conclusion that the Grid FM sandstone has the potential to act as parent sand for injectite complexes. Seismic inversion and AVO studies, accomplished in 2014/2015 however found strong proof that the high amplitudes are due to carbonate cementation, thus leaving a high risk for effective reservoir presence and trapping mechanism.

In-house studies, based on reports of APT and FIT were accomplished to investigate the petroleum system in the greater PL457 area. The Upper Jurassic hot shales are the primary hydrocarbon source rock for all discoveries in the area. These units are not deposited on the Utsira High, but are deposited in the Viking Graben which is the main kitchen area. At present



day these organic rich units are estimated to be at oil peak expulsion. Onset of expulsion is at about 4200 m under HpHt conditions. The late Jurassic sand systems reaching out in to the basin centre allow for effective migration up to the Utsira High from multiple directions. This is reflected in the hydrocarbon accumulations encountered on and near the Utsira High. All accumulations display different hydrocarbon compositions and saturation. In addition the water properties vary across the Utsira High area. For hydrocarbon traps within the Tertiary section, fault related migration is the key for understanding the charging mechanism. In PL457, migration from Draupne FM into the Paleocene is supposed to occur via faults with large displacement southwest of the license area. From there, the migration path passes along the prominent Utsira High west fault and eventually spills into the area of the Paleocene Balder, Grane, Svalin fields. Fig. 3.1

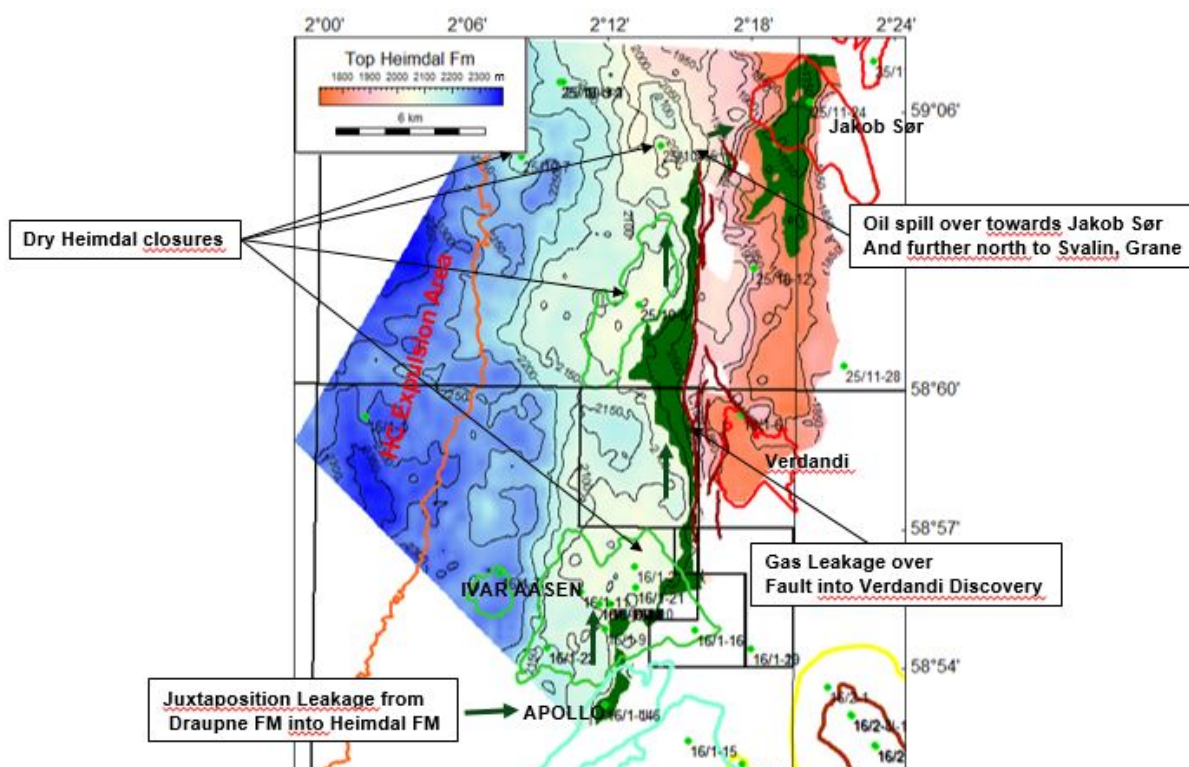


Fig. 3.1 PL 457 - Hydrocarbon migration model

## 4 Prospect Update report

The application for PL457 in 2007 was based on the Eocene/Oligocene Aglaja prospect, a high seismic amplitude feature northeast of well 16/1-16 (Fig. 4.1). It was supposed to be a Grid FM sandstone, injected into Eocene/Oligocene shale, in analogy to the Volund field. The original volume calculation came up with large volumes and a moderate risk. Investigations on seismic amplitudes meanwhile suggest that the high amplitudes are caused by cementation, thus implying a high risk for reservoir quality and trap configuration and consequently reducing the anticipated HC volumes considerably.

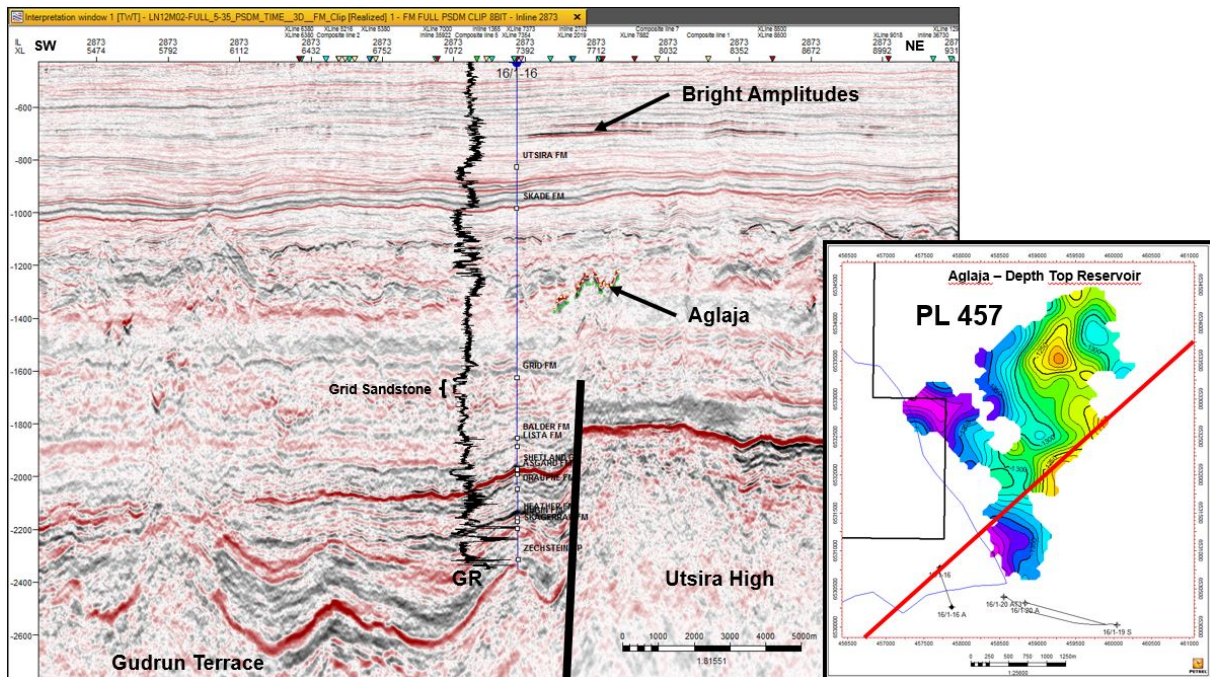


Fig. 4.1 PL457 - Aglaja prospect

Several prospects/leads have been identified in license PL457 between 2008 and today.

The PL457 part of the Asha prospect was successfully tested in the Middle Jurassic Hugin FM and the Skagerak FM sandstone by well 16/1-16 and 16/1-16A in 2012. Subsequently the PL457 discovery area was carved out for the hydrocarbon bearing stratigraphic interval and included into the Ivar Aasen field development. The Upper Jurassic/Lower Cretaceous Noor prospect on top of the Asha prospect was tested dry, probably due to missing retention capacity of the top seal and/or side seal.

The Asha East prospect, a hanging wall 3-way dip closure on Middle and Upper Jurassic level southeast of Ivar Aasen was tested dry by well 16/1-20A in 2013, probably due to missing side seal.

The Lower Cretaceous/Weathered basement prospect Amol was tested dry due to tight reservoirs by well 16/1-19S in 2013. Fig. 4.2



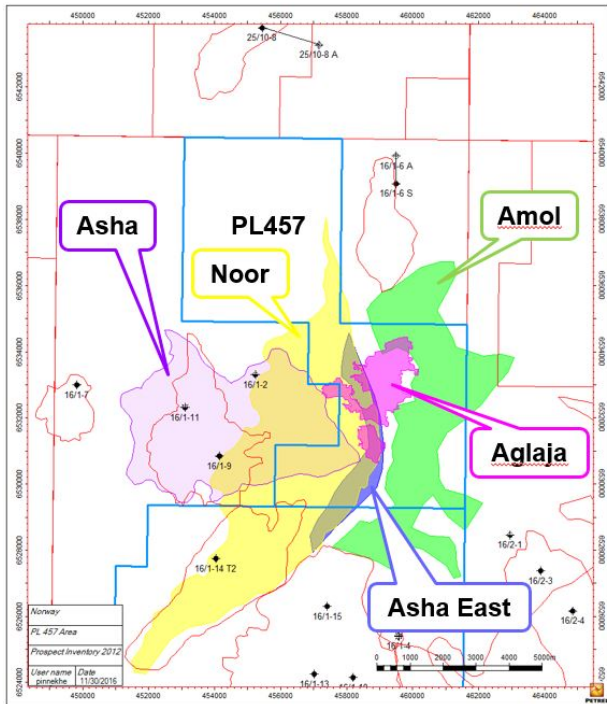


Fig. 4.2 PL457 - Prospect Inventory 2012

The remaining potential in PL457 after drilling Asha/Noor, Asha East and Amol consists of leads/prospects which are either small or high risk and is not considered economically viable. Fig. 4.3

**OIIP [MMm<sup>3</sup>] oe**

Lead	Mean	P90	P50	P10	GPOS
Asha	53.80	25.80	49.60	87.30	80.0
Asha-East	11.80	2.49	9.32	25.40	49.0
Amol	44.40	21.80	40.40	72.70	43.3
Noor	53.80	18.50	46.60	98.30	34.6

**Ressources [MMm<sup>3</sup>] oe**

Lead	Mean	P90	P50	P10	GPOS
Asha	53.80	25.80	49.60	87.30	80.0
Asha-East	11.80	2.49	9.32	25.40	49.0
Amol	44.40	21.80	40.40	72.70	43.3
Noor	53.80	18.50	46.60	98.30	34.6

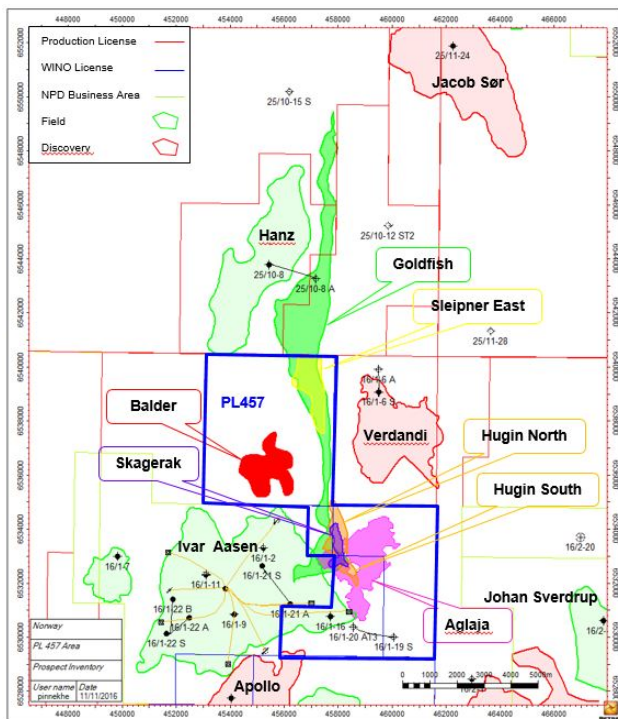


Fig. 4.3 PL457 - Lead/Prospect Inventory 2016 with comparison to license application 2007

**OIIP [MMm<sup>3</sup>] oe**

Lead/Prospect	Mean	P90	P50	P10	GPOS
Aglaja	6.73	1.32	5.54	13.80	14.4
Aglaja APA 2007		13.53	19.16	24.89	18.0
Goldfish	5.75	0.45	2.71	14.10	16.8
Goldfish PL 457	1.36	0.07	0.56	3.30	16.8
Balder	0.19	0.03	0.13	0.44	28.8
Hugin North	1.00	0.25	0.77	2.05	31.5
Hugin South	0.23	0.06	0.17	0.47	31.5
Sleipner East	0.49	0.12	0.36	1.01	35.0
Skagerak Sst.	0.20	0.03	0.14	0.46	32.0

**Ressources [MMm<sup>3</sup>] oe**

Lead/Prospect	Mean	P90	P50	P10	GPOS [%]
Aglaja	0.99	0.18	0.77	2.09	14.4
Aglaja APA2007		3.64	5.79	7.93	18.0
Goldfish	2.20	0.14	0.98	5.54	16.8
Goldfish PL 457	0.52	0.02	0.20	1.28	16.8
Balder	0.07	0.01	0.05	0.15	28.8
Hugin North	0.39	0.09	0.30	0.81	31.5
Hugin South	0.09	0.02	0.07	0.19	31.5
Sleipner East	0.20	0.05	0.14	0.41	35.0
Skagerak Sst.	0.08	0.01	0.05	0.19	32.0

Potential traps on Upper Triassic to Middle Jurassic level are small hanging wall 3-way dip closures with a considerable side seal risk (Sleipner East, Hugin N, Hugin S, Skagerak Sst.).

The Paleocene Goldfish prospect (Heimdal FM) is the largest remaining prospect in PL457 with most of the closure located outside the license. It is a hanging wall closure on Heimdal FM level, partly stratigraphic, with a poorly defined side seal being the major risk. Fig. 4.4

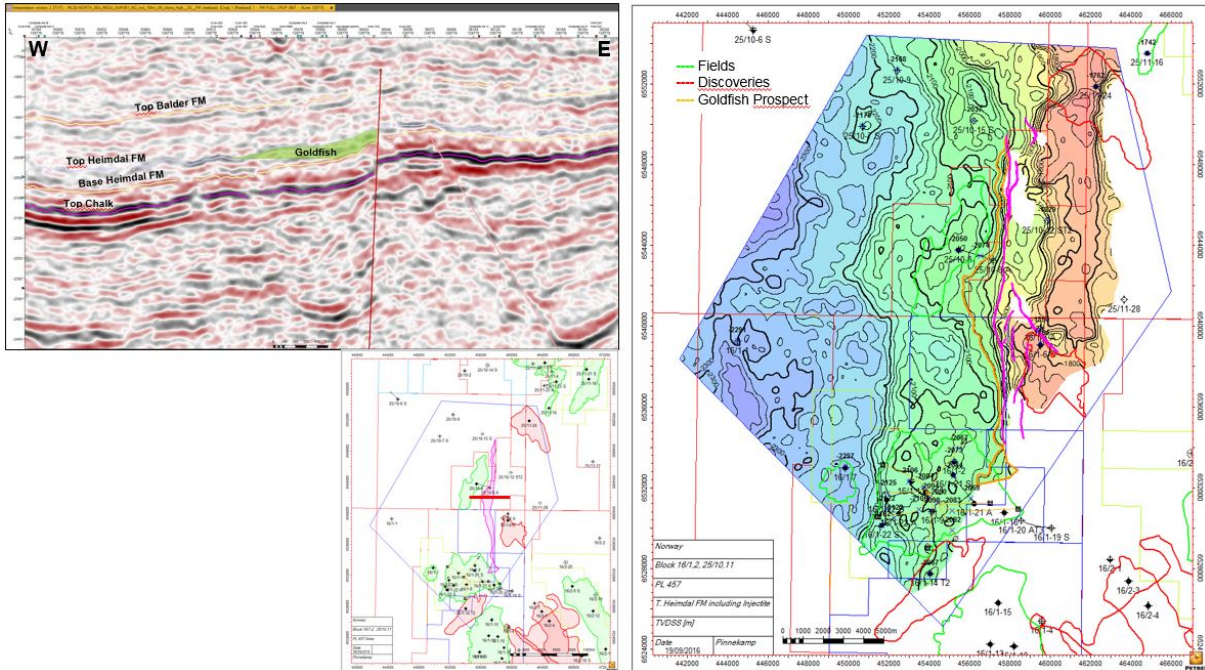


Fig. 4.4 PL457 - Goldfish prospect

The only 4-way dip closure in PL457 is the Balder lead, which is structurally well defined, but areally very small. Moreover migration of hydrocarbons into the structure is a major risk.

## 5 Technical evaluations

The Asha discovery (well 16/1-16 and 16/1-16A) was included in the Ivar Aasen field development. The base case for the recoverable resources in Ivar Aasen (without West Cable) is currently 27,2 MMm3 o.e. Fig. 5.1

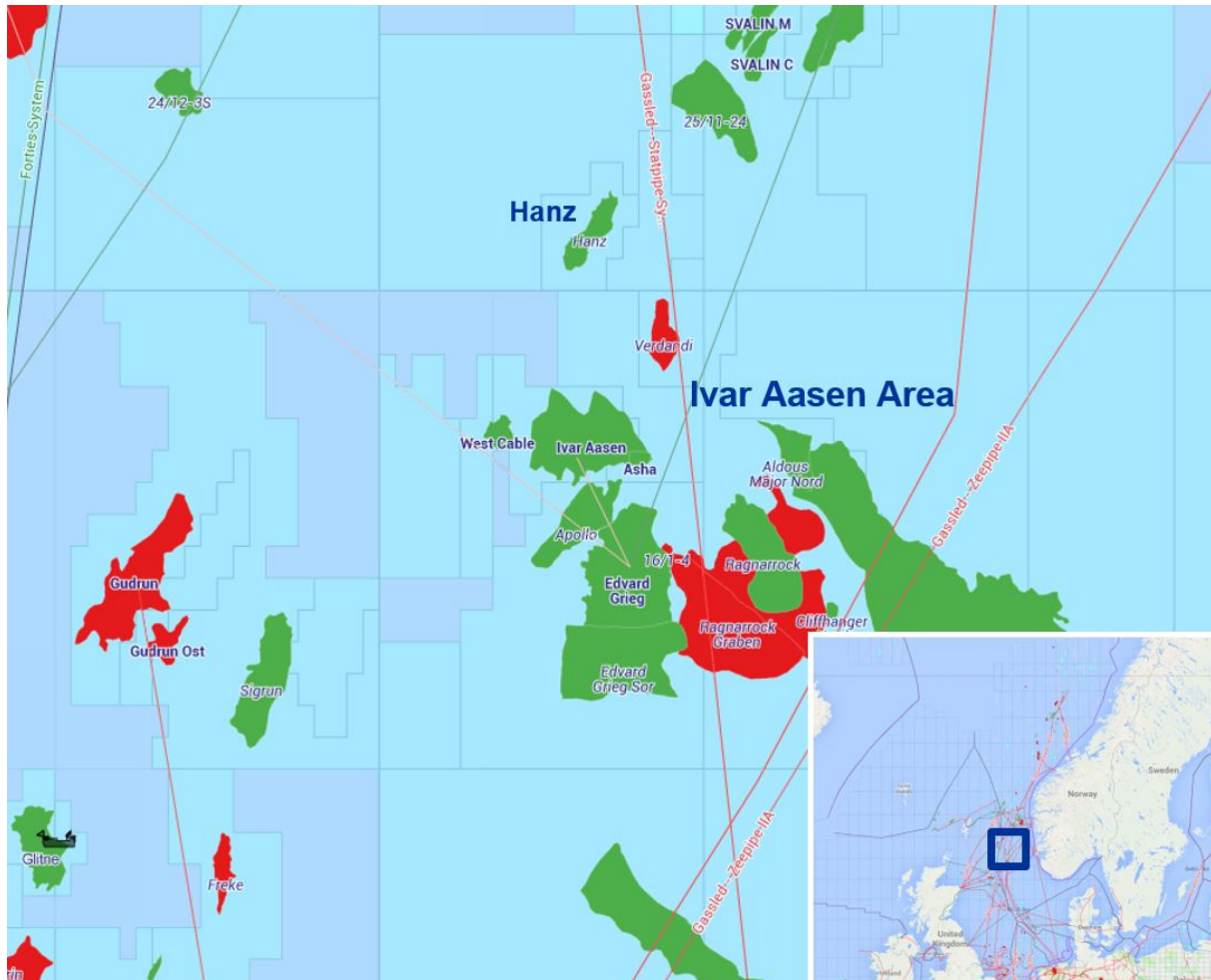


Fig. 5.1 Ivar Aasen Field

## 6 Conclusions

All prospects within the licensed area featuring an attractive volume assessment and good chances of success were drilled in 2012 and 2013. Only the Asha prospect, an extension of the Ivar Aasen discovery successfully tested hydrocarbons. The Noor, Asha-East and Amol prospects turned out to be dry. The concepts of hydrocarbon traps in Lower Cretaceous/Jurassic hanging wall 3-way dip closures as well as in weathered basement had subsequently to be downgraded.

The extended license period was used to re-evaluate the potential in PL457 incorporating all available data from recently drilled wells. In summary, the remaining prospectivity in PL457 is low. The only prospects of adequate size, Goldfish and Aglaja, are considered as prospects with an extremely high risk. No further drilling project could be matured. Wintershall Norge AS therefore recommended to fully surrender PL457. The recommendation has been accepted unanimously by all license partners.



