PL 597 – PL597B Relinquishment report

A COMPANY IN THE VNGGROUP

VNG Norge

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Document last updated 14.03.2014 12:05 CET

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1 Key licence history

Production Licence (PL) 597 was awarded to VNG Norge AS (operator, 40%, referred to hereafter as VNG Norge), Maersk Oil Norway AS (30%, referred to hereafter as Maersk) and Dana Petroleum Norway AS (30%, referred to hereafter as Dana) on 23 May 2011 as part of the 21st Norwegian Sea licencing round. It covers approximately 428 km^2 in the block 6506/5. Initial work obligations and periods were defined as follows:

- Reprocessing of 3D seismic
- Within two years: drill-or-drop decision (13 May 2013)
- Within three years: send a status report to the Ministry of Petroleum and Energy, and the Norwegian Petroleum Directorate (13 May 2014)
- Within four years: drill a well (13 May 2015)
- The initial period expires after five years (13 May 2016)

The licence group was awarded PL 597B on 23 January 2012, as an award in predefined areas (APA 2011). It covers approximately 146 km^2 in blocks 6506/8 and 6506/9. The licence comprised of PL 597 and PL 597B will hereafter be referred to as PL 597.

Due to delays in seismic reprocessing (due to , the licence group asked for a seven-month extension of the drill-or-drop decision date. This was granted by the Ministry and he drill-or-drop date was postponed from 13 May to 13 December 2013.

On 03 OCtober 2013, the operator porposed to the partnership that a well should be drilled in PL 597 in the Herzer prospect. Both partners voted against this recommendation. VNG Norge asked for a 6-month extension of the drill-or-drop decision on 09 December 2013 in order to establish a new partnership and secure a positive drill decision for an exploration well. This extension was not granted, and, as a result, the licence expired on 13 December 2013.
The reason for relinquishment is the negative drill decision made by the licence group: despite a drill recommendation of the Herzer prospect presented by VNG Norge, resources in the prospect were considered too small by Maersk and Dana to support a field development.

During the life of the licence, a number of meetings took place and were documented:

- 14 June 2011 - joint Exploration Committee (EC) and Management Committee (MC) meeting
- 26 October 2011 - EC meeting
- 30 November 2011 - MC meeting
- 07 December 2012 - joint EC and MC meeting
- 11 March 2013 - EC meeting
- 02 May 2013 - EC meeting
- 01 July 2013 - EC meeting
- 03 October 2013 - Work meeting
- 19 November 2013 - MC meeting

2 Database

Seismic Database

The main addition to the seismic database was the merged and reprocessed VNG12M02, conducted by CGG. It is comprised of parts of three surveys, two of them already present in the database (MN9602 and SKHN99) and one purpose-purchased survey (BG0801, also added to the seismic database). The Herzer prospect and various leads in the licence area are amplitude-driven: it was then decided to perform an amplitude-preserving controlled-beam depth migration (APCBM) rather than using a Kirchhoff algorithm, which may have affected the amplitude content. The data were received as time and depth volumes, with the following vintages sets: full, near, mid, far, ultra far (in both time and depth domains) Parts of VNG12M02 later went through a pre-stack conditioning study, performed by SharpReflection: this survey is referred to as VNG12M02 Cond. (see Fig. 2.1).

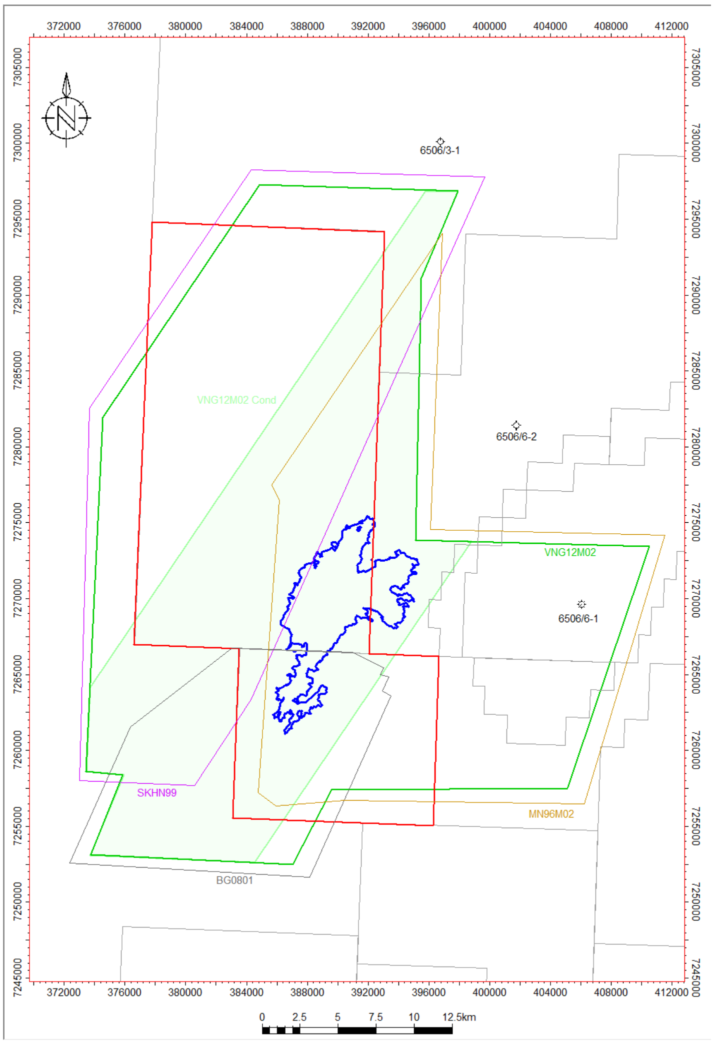

Fig. 2.1 VNG12M02: merged and conditioned data. ***MN9602 (orange outline), SKHN99 (pink outline), BG0801 (grey outline) were merged and reprocessed into VNG12M02 (green outline), which was later partly conditioned (VNG12M02_Cond, green shading)***
Herzer prospect is shown with blue outline.

Other surveys, listed in the database in the application, were kept: 3D PGS MegaMerge; 2D MNR05, MNR07, MNR08, MNR09.

Well Database

Albert well, 6506/6-2 was drilled in 2013 in PL 513, neighbouring licence to PL 597. As VNG Norge farmed into the licence in December 2012, the results of 6506/6-2 were used for Herzer evaluation and the well was added to the database. All other wells, listed in the database in the application, were kept.

3 Review of geological framework

A series of studies, ordered and coordinated by the licence group, helped mature the geological framework within PL 597 acreage.

Hydrocarbon generation and migration

A regional basin modeling study was conducted over the Dønna Terrace by Exploro (Exploro, 2013). It identifies four valid source rocks in the licence acreage: mainly Late Jurassic Spekk Fm, but also Callovian Melke Fm, Early Jurassic Åre Fm and a Cenomanian source rock (penetrated by well 6506/11-3). TImeline for hydrocarbon generation, expulsion and migration is illustrated on Fig. 3.1. Present day average geothermal gradient is 37 ºC/km.

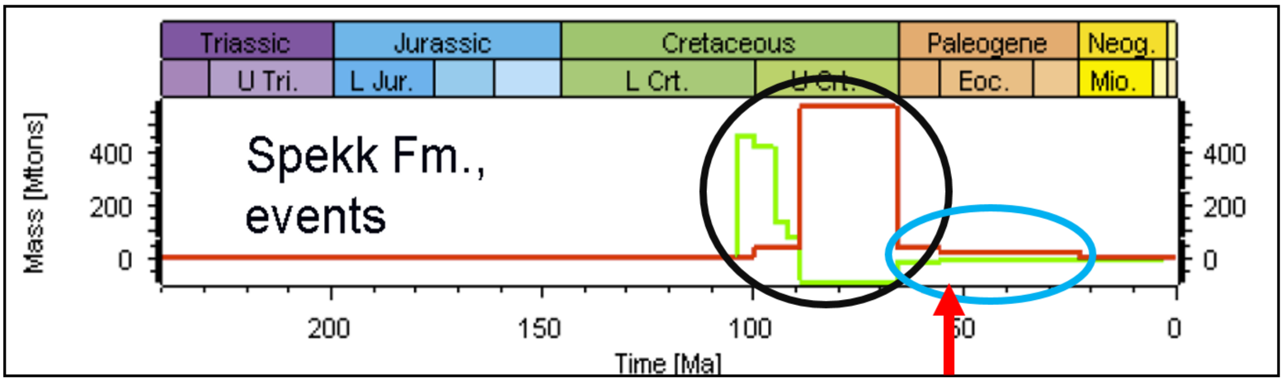

Fig. 3.1 Hydrocarbon generation, expulsion and migration timeline. Spekk Fm. *Oil is depicted in green, gas in red.*
The red arrow points at the trap formation of Herzer prospect.
The black shape highlinghts the main expulsion of hydrocarbons.
The blue shape highlights the migration of hydrocarbons charging the Herzer prospect.

Gross depositional environment

Gross depositional environment (GDE) maps were updated according to the results of the biostratigraphy study (Petrostrat, 2013) and the stratigraphy study (AppliedStratigraphix, 2012). Fig. 3.2 illustrates the three events for deposition of Lysing Fm. sandstones in the Dønna Terrace.

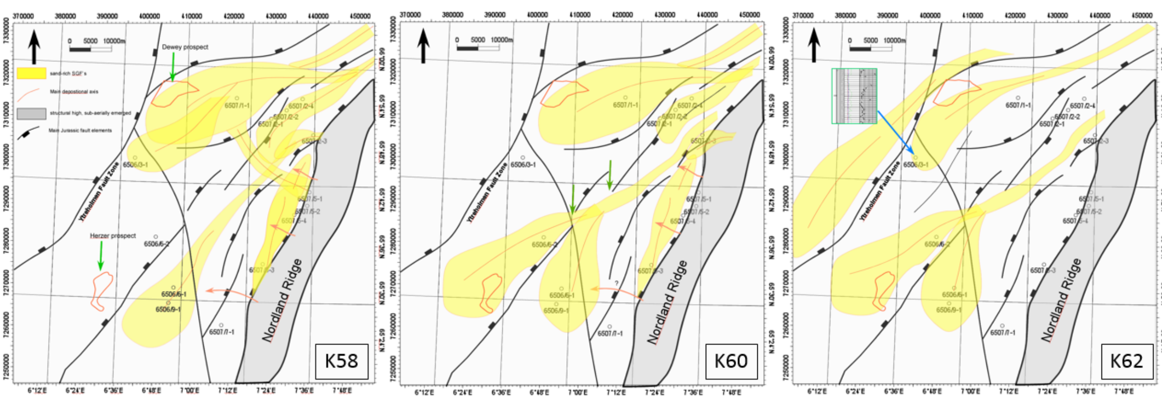

Fig. 3.2 Lysing GDE Maps

Albert well, 6506/6-2

Results from Albert (completed in February 2013) well were used extensively in PL597. VNG Norge conducted a dry-well-analysis to build confidence in the gas presence within Herzer prospect. A summary of well data is shown on Fig. 3.3 and Table 3.1. The very low Net-to-Gross ratio of Lange Fm. made it non-prospective.

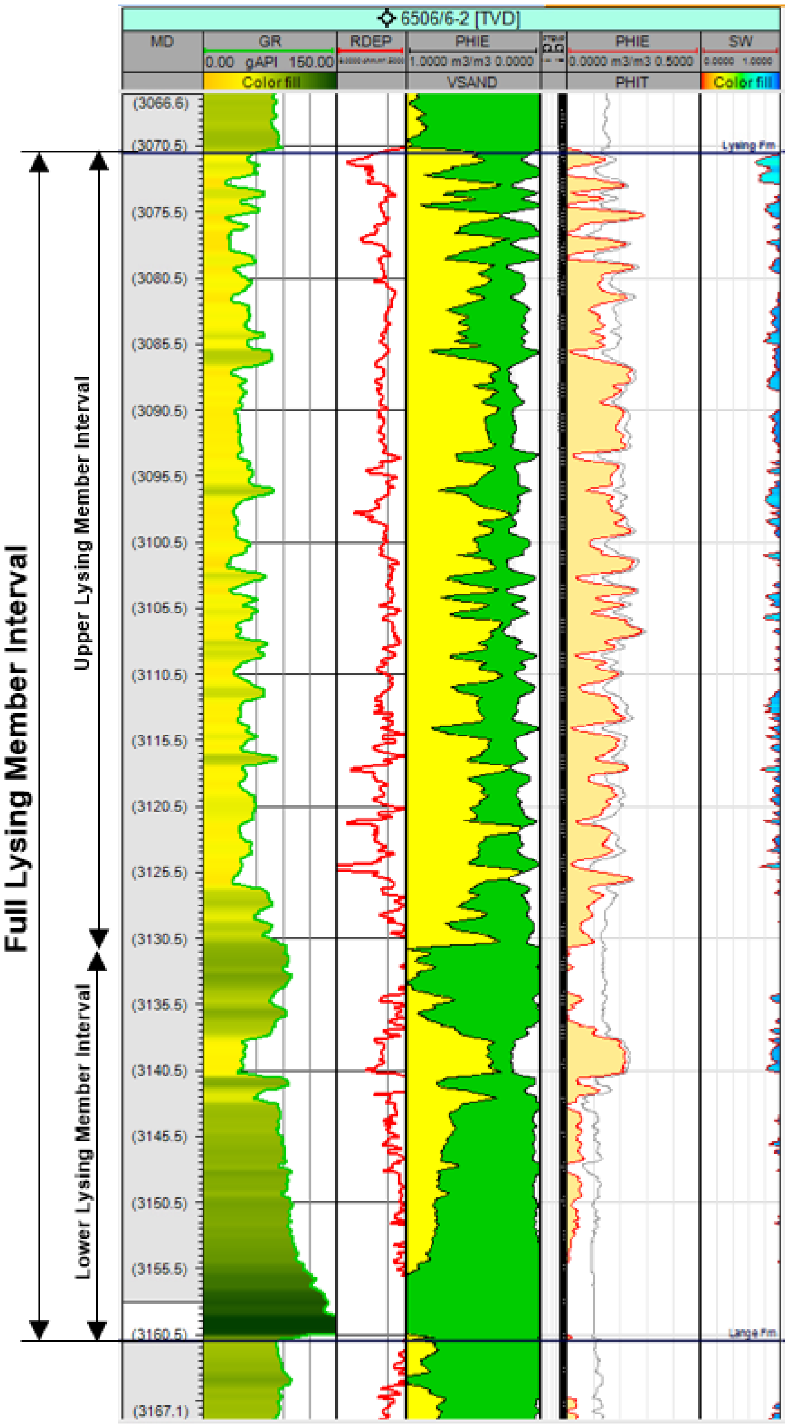

Fig. 3.3 6506/6-2 Albert: VNG CPI

Table 3.1 6506/6-2: Reservoir Parameters

	Top (mRKB)	Bottom (mRKB)	Gross (mRKB)	Net Sand (mRKB)	N/G	Phi (avg)
Upper Lysing	3071	3137,3	66,3	56	0,85	0,2
Lower Lysing	3137,3	3161	23,7	3,5	0,15	0,195

Seismic data quality

Despite reprocessing and conditioning, seismic data quality remained a challenge during the licence lifetime; a range of pitfalls were identified and addressed during geological and geophysical evaluation:

- Noise level: for the sake of amplitude preservation, rather gentle parameters were chosen for noise attenuation in the reprocessing sequence. This is especially valid for the pre-stack mute angles: the conditioning study revealed a concerning noise level in near-, far- and ultra-far offsets of the reprocessed volumes. Attempts to eliminate this noise proved partially successful, but the angle range for near- and far partial stacks was reduced and ultra-far partial stack was not produced at conditioning stage.
- Seabed: rough bathymetry, made of morainic deposits and sharp terrace edges, sets up multiples and diffracted noise.
- Slide: a significant quantity of sediments collapsed from the Paleocene inversion dome and slid down its flanks. They are interpreted as reworked and more porous than their in-place counterparts (Welbon et al. , 2007): they thus absorb seismic energy, which results in a poorer imaging underneath the slid sediments, compared to under the intact sediments.
- Anisotropic overburden: challenging velocity modelling and time-to-depth conversion

Top Lysing seismic response

In collaboration with Ikon, a comprehensive internal study of the rock physics response, together with fluid substitution analysis on Albert well data, enabled a precise definition of the seismic response of Top Lysing (see Fig. 3.4):

- where Lysing Fm. sandstones are brine-bearing, such as in 6506/6-2, the downward transition from Kvitnos Fm. shales into Lysing Fm. sandstones corresponds to a weak increase in acoustic impedance on the full-offset stack (displayed as a blue peak)
- downward transition between Kvitnos Fm. shales and hydrocarbon-filled Lysing Fm. sandstones corresponds to a zero-crossing (from a weak peak to a strong trough) on the full-offset stack.

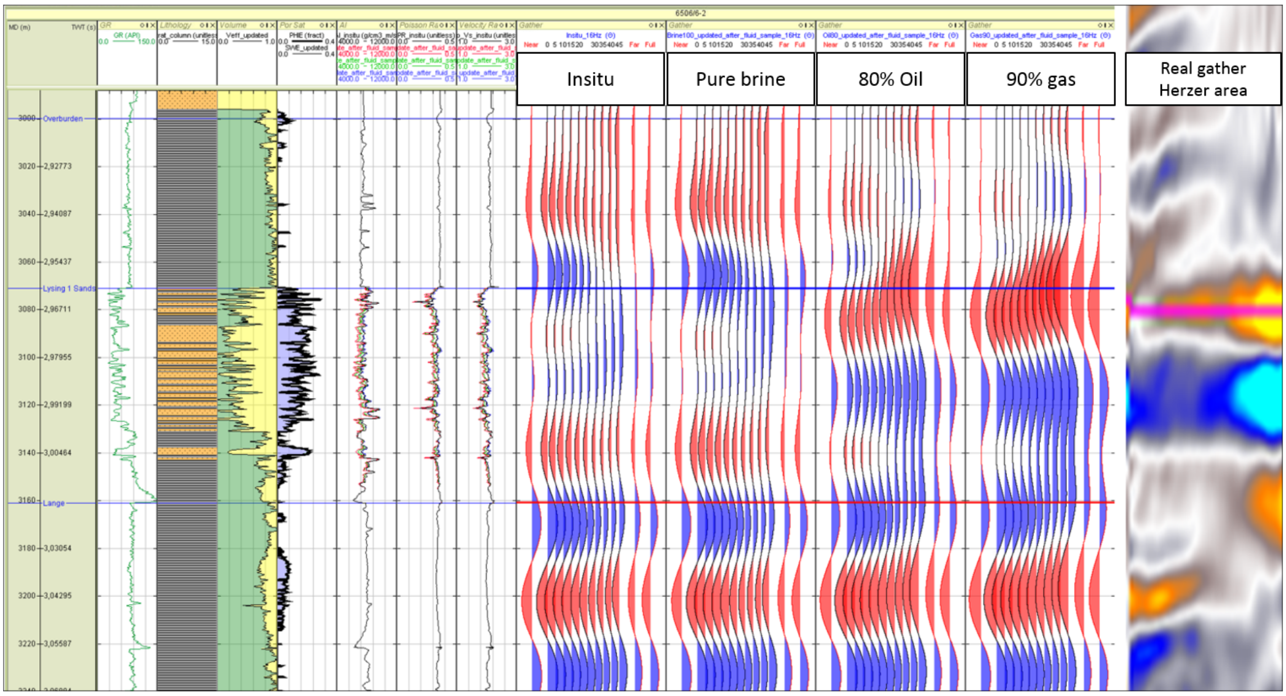

Fig. 3.4 Top Lysing seismic response at 6506/6-2, in-situ and fluid substituted. Comparison with Herzer area.
In 6506/6-2, in-situ and pure brine response are very similar and confirm the petrophysical evaluation (less than 5% hydrocarbon in the Lysing sandstones at well location): Top Lysing appears as a weak increase in acoustic impedance, represented by a blue peak, on the full-offset stack
Fluid substitution, using Gassman's equations, shows a drastic change in response: Top Lysing now appears as a decrease in acoustic impedace on the full-offset stack,
Interestingly enough, gathers collected within the Herzer prospect show a very similar response to the gas-filled response of Albert

4 Prospect update

Focus has been kept on the Herzer Lysing prospect. No other lead at Lysing level was upgraded to prospect: either their sizes were too small, or the seismic quality did not allow to increase confidence in their definition (Riesling). Leads in Lange Fm. (very low N/G in Albert well) and Upper Jurassic (too deep) were not upgraded to prospects either.

The Herzer prospect was mapped on the VNG12M02_Cond full stack depth cube. Fig. 4.1 and Fig. 4.2 show sections across the Herzer prospect. Fig. 4.3 shows a depth map of the prospect, with hydrocarbon-water contact distribution.

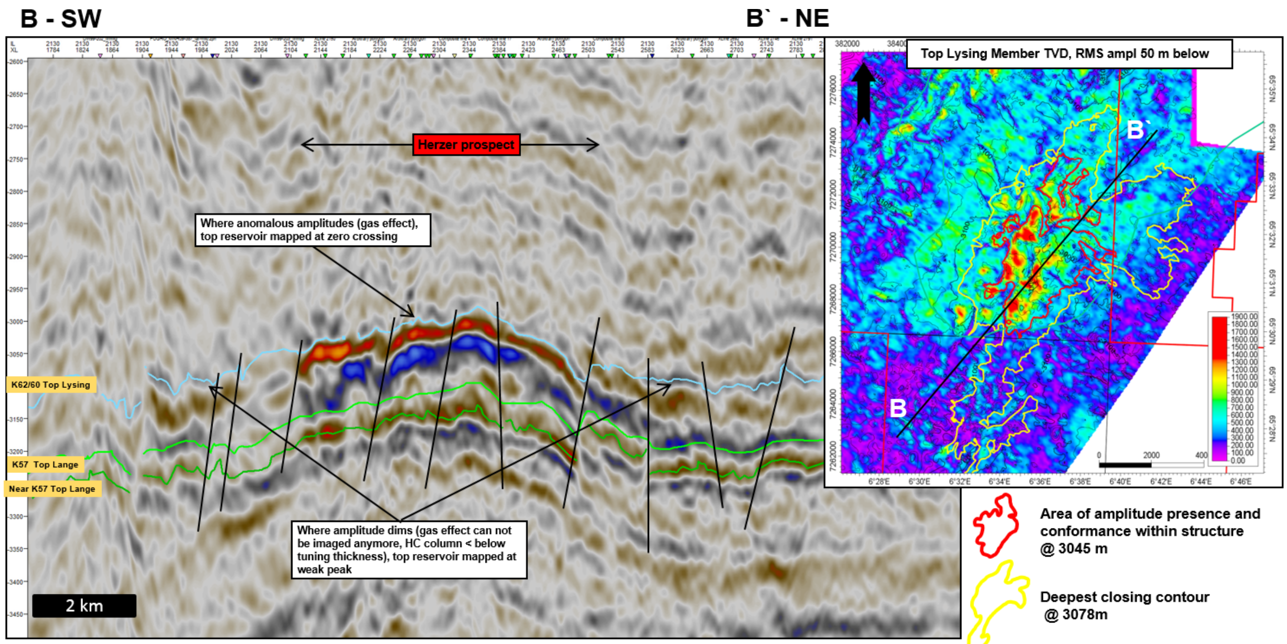

Fig. 4.1 Herzer prospect: SW-NE cross section. ***InLine 2130, VNG12M02_Cond full depth. RMS amplitudes show good conformance with structure at 3045 mTVDss. This contour therefore defines the hydrocarbon-water contact P90 value.***

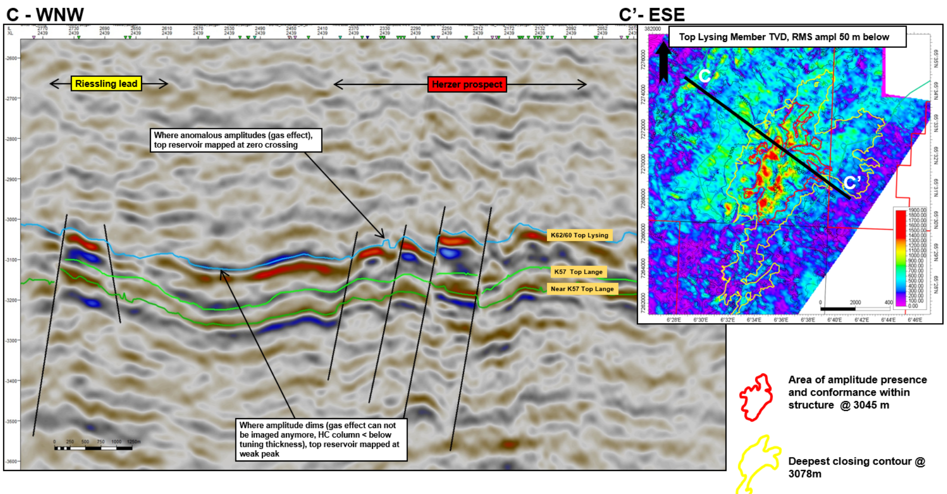

Fig. 4.2 Herzer Prospect: WNW-ESE cross section. ***XLine 2439, VNG12M02_Cond full depth***

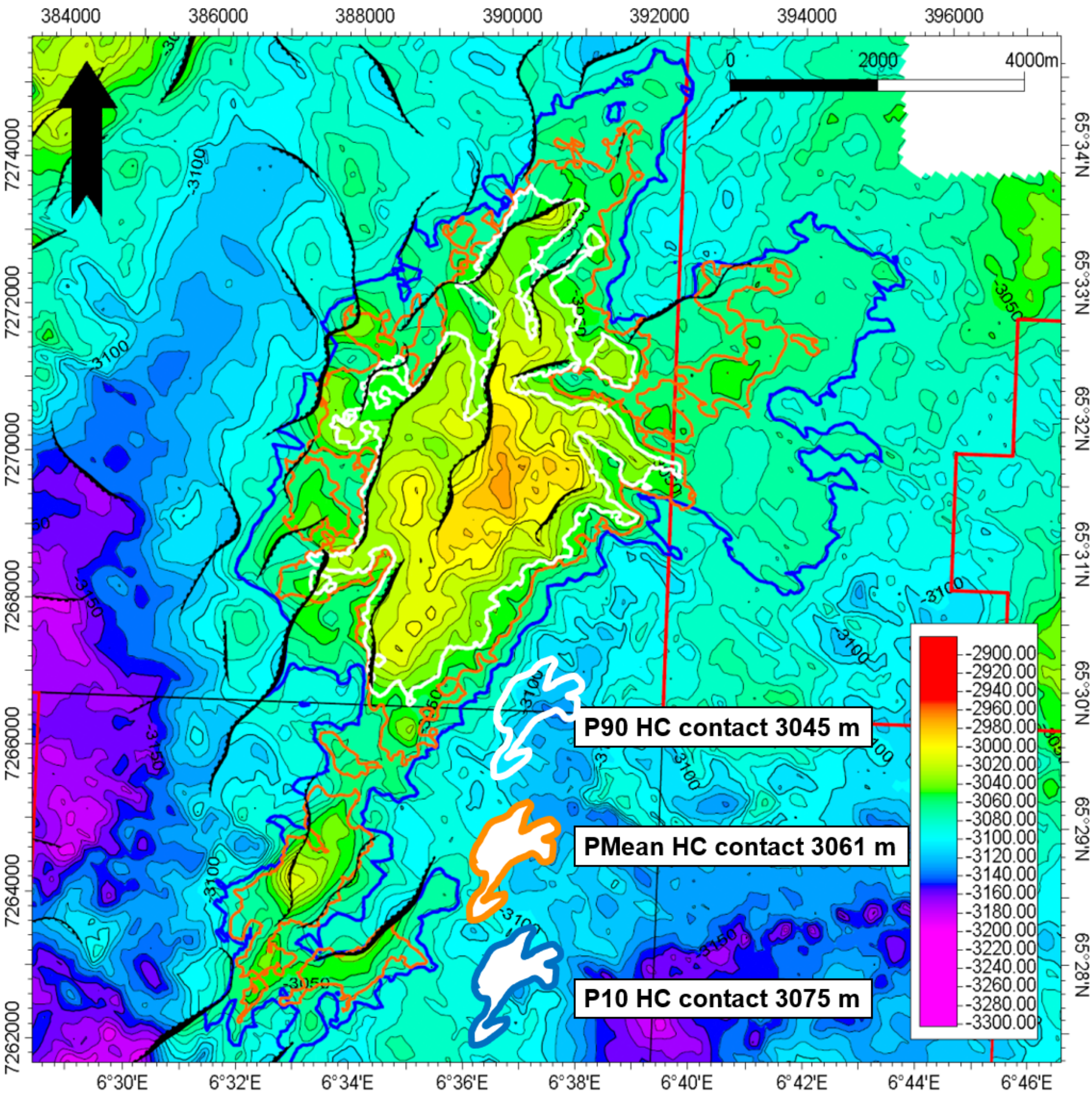

Fig. 4.3 Herzer Prospect: Depth Map With Hydrocarbon-Water Contacts. ***Contour interval: 10 m***
P90 HC contact: 3045 mTVDss, amplitude conformance with structure
P10 HC contact: 3075 mTVDss, 3 meters above structural spill-point at 3078 mTVDss

Reservoir Presence and Effectiveness. Probability P1 = 0,80

High porosity, good permeability sandstones of the Lysing Fm. were penetrated in the Albert well. Lysing sand package is mapped with confidence from Albert into Herzer.

Trap Presence. Probability P2 = 0,80

The Herzer prospect is mapped as a medium-relief four-way dip closure, present in both time and depth in the data set. Lateral velocity variations still create uncertainty in the imaging precision.

Migration and Charge. Probability P3 = 0,60

Timing is the key risk for the Herzer prospect: the trap was formed as a result of a Palaeocene inversion. At this time, as described in 3 Review of geological framework, most hydrocarbons were expelled from source rocks already. The charge of Herzer prospect then relies on secondary cracking, the transformation of already-expelled oil into gas. As shown on Fig. 3.1 for Spekk Fm., this process, lasting until the end of Oligocene, enables hydrocarbons to migrate up at a later stage, when Herzer trap is formed.

Seal presence and effectiveness. Probability P4 = 0,70

A thick section of shales of the Kvitnos Fm. is mapped throughout the entire Dønna Terrace, and proven in Albert well. Small faults on the crest of Herzer are not interpreted to reach thief sand layers (approximately 180 metres above Top Reservoir)

Geological chance of success for Herzer prospect: Pg = 0,27

Extensive seismic data analysis study enabled to define the signature of a gas-water contact within Herzer: transposing and altering Albert well data to Herzer structure allowed to identify a suitable model triggering the observed response on real seismic data: the best match between model and real data from Herzer is obtained for a fill-to-spill scenario, with 90 % gas saturation in a similar sandstone as in Albert. At contact depth, modelled amplitudes display an abrupt change, which is visible on actual data. Therfore, a direct-hydrocarbon-indicator uplift was applied to the geological chance of success.

Total chance of success for Herzer prospect: P = 0,41

The prospect model can then be summarized as follows: the crest of the Herzer closure is located at 2975 mTVDss, and the Lysing sandstone has an expected thickness of 95 m. The structural spill point, located in the North-East of the prospect, is defined at 3078 on the depth-domain seismic.

Sandstones of the Lower Turnonian to Upper Coniacian Lysing Fm. on the Dønna Terrace show a porosity range of 10% to 28%. These porosity values are valid for both lobe and channel complexes, but lobe systems, as expected in the Herzer prospect, display higher permeability values. Calcitic cementation is likely, but its presence is expected limited to the uppermost few metres of the reservoir, as seen in the Albert well (6506/6-2) 15 km away. Its impact on reservoir quality is therefore considered limited. Petrophysical analysis indicates very good lateral communication of lobe reservoirs, with high deliverability.

Marulk field was used as an analogue for fluid parameters estimation. Other exploration wells (6506/6-2, 6507/2-2, 6506/12-3, 6506/11-3, 6506/12-4) also contributed, though drill-stem tests results, pressure and temperature measurements, to the reservoir evaluation of the Herzer prospect.

This evaluation results in the following resource estimation:

Table 4.1

Table 4.1 Herzer resource table

In Place Resources		P90	Mean	P10
Gas	[1e9 Sm3]	10,9	20,7	34,0
Total Resources	[1e6 Sm3 OE]	11,9	22,7	37,4

Recoverable Resources		P90	Mean	P10
Gas	[1e9 Sm3]	7,1	13,3	22,2
Condensate	[1e6 Sm3 OE]	0,51	1,4	2,19
Total Resources	[1e6 Sm3 OE]	7,19	14,5	24,3

To producte gas from Herzer prospect, drainage strategy is natural depletion, with an estimated mean recovery factor of 64%. The average gas production rate is 1.8 MSm3/d of gas, assuming 6 producers. The production wells are highly deviated to horizontal, to ensure sufficient productivity along the structure. Expected gas quality is based on Marulk discovery well (3-4% CO_2). Fig. 4.4 shows the truncated base production profile for Herzer.

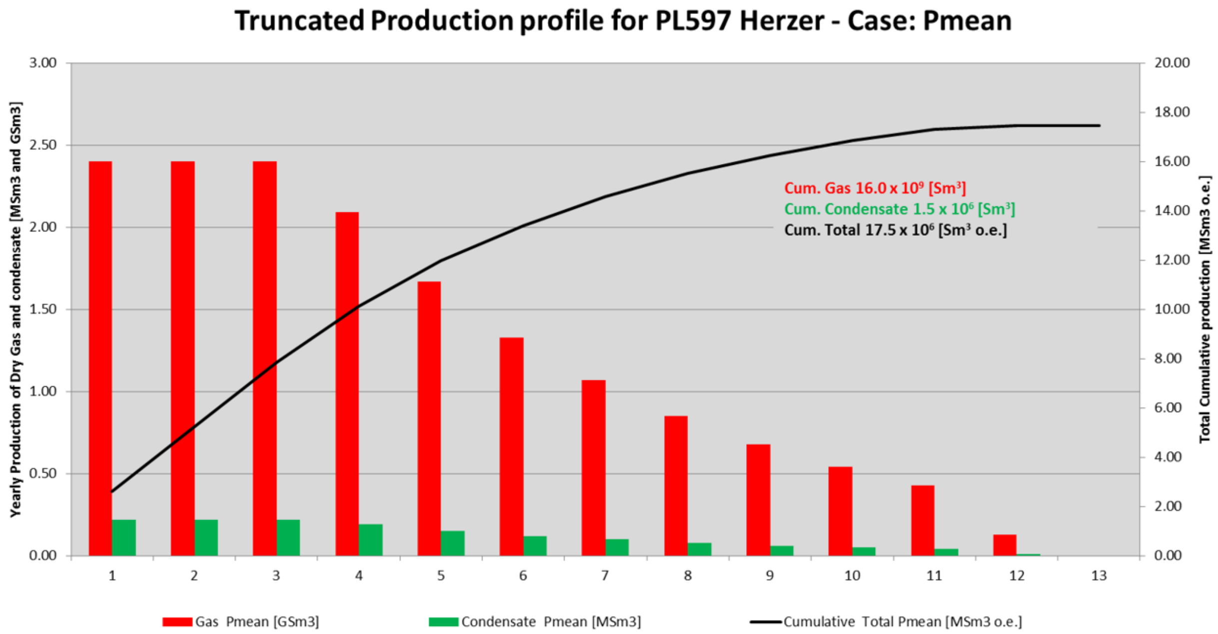

Fig. 4.4 Herzer: Base production profile (truncated). ***Plateau production is expected to last for three years, then gently decrease for the following 9 years, yielding to a total production period of 12 years***

5 Technical evaluations

A technical and economical evaluation of the Herzer prospect was conducted in 2013. It results in robust, positive economical indicators and can be summarized as follows.

Field Development plan

Herzer is planned to be developed with 6 gas producers, using two 4-slot templates and hence two drill centres. This solution is well suited to the water depth (approximately 400 metres in the prospect area) and also offers spare slots, as well as an optimization of well locations. Risks and costs related to heavy lift of 6-slot template are spared, too.
Gas produced from Herzer prospect can be tied back to the processing facilities of Åsgard B, located 50 km Sout-West of Herzer prospect. To avoid formation of hydrates, pipe-in-pipe with direct electrical heating (DEH) is the preferred solution. Condensate is to be sold free-on-board at Åsgard A, whereas Åsgard Transport System (Area B) is planned to transport gas to Kårstø terminal. Export to the United Kingdom and continental exits (Area D) follows.
In the case of a production start as early as 2020 (VNG Norge base case), capacity is assumed at Åsgard B processing facilities and Åsgard Transport System. Uncertainties remain in the DEH feasibility (the technology is still somewhat immature, especially for such long distance) as well as the CO_2 handling capacity at Åsgard B, which may have to undergo a topside modification (see CAPEX analysis below).

Development, Production and Decommissioning Costs

The following costs are calculated for a 100% share in the licence.

- CAPEX is estimated at 8242 million Norwegian Kroner (MNOK), with the following breakdown:
  - Host modification: 500 MNOK
  - Subsea and pipeline: 4553 MNOK
    - Pipeline: 3114 MNOK (46 MNOK/km)
    - Subsea installations: 1439 MNOK
  - Production wells: 3189 MNOK (532 MNOK/well)
- OPEX
  - Fixed OPEX at 122 MNOK/year
  - Oil processing tariffs at Åsgard B: 96 NOK/Sm^3
  - Gas processing tariffs at Åsgard B and Kårstø: 201 NOK/Sm^3
  - Gas export tariffs Åsgard Transport System: 181 NOK/1000Sm^3
  - NGL processing tariffs at Kårstø: 302 NOK/Sm^3 O.E.
- Decommissioning costs is estimated at 1298 MNOK

Based on best available input data to VNG Norge, the economical conclusions are as follows:
The net present value (NPV) of the Herzer project is positive and robust.
The expected monetary value (EMV) is positive and robust.

6 Conclusions

Internal evaluation resulted in a positive value in the Herzer project.
In addition to Herzer, a number of leads in the Lysing Fm. sandstones were identified (seeFig. 6.1). Riesling South and North, the larger of them could not be upgraded to prospect, because of too poor seismic data quality. Where data allows, indicators for hydrocarbon presence (seismic amplitude anomalies, favourable structural position for migration) show the potential of these two leads. All other leads mapped at Lysing Fm. level also show potential, but are all very small.

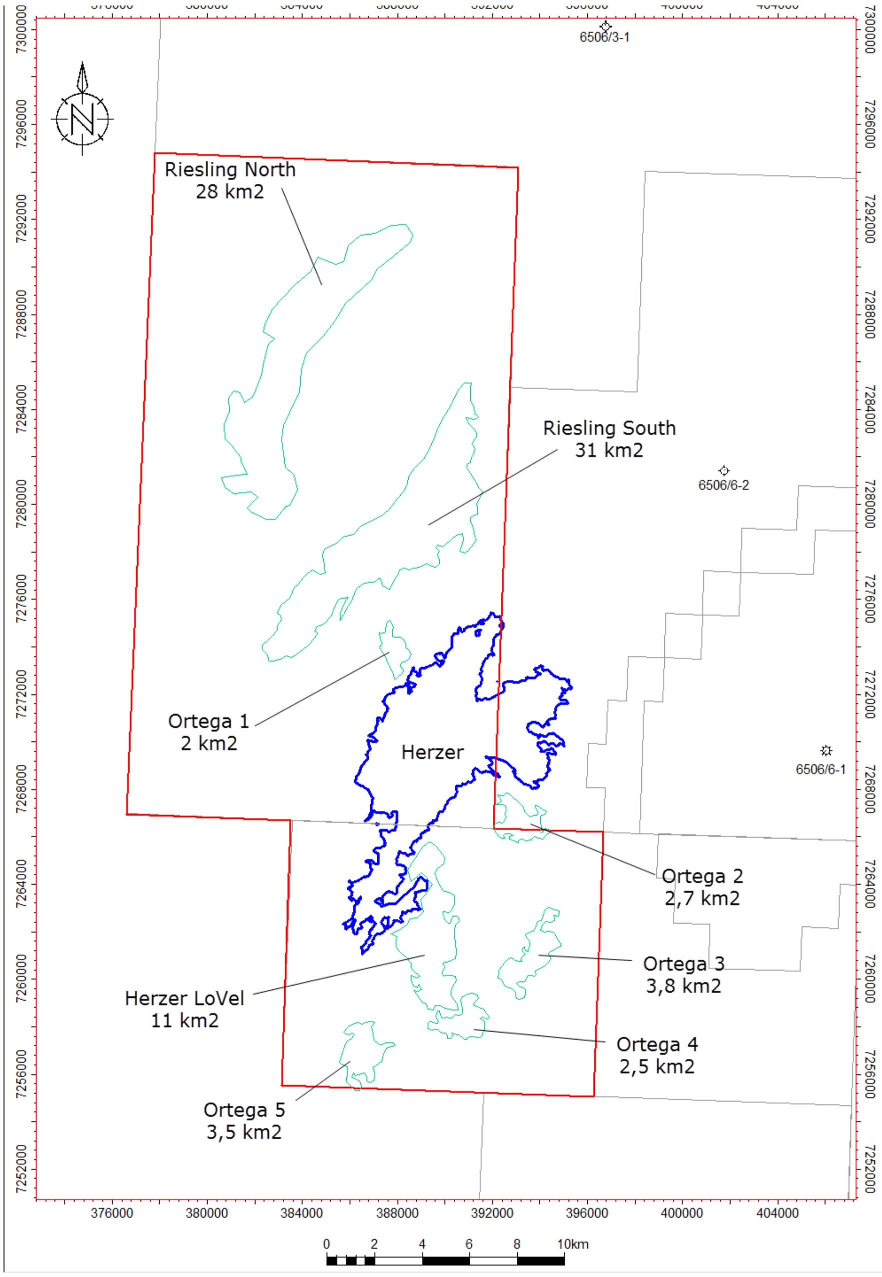

Fig. 6.1 PL 597: Prospect and Leads. ***Herzer prospect is shown with blue contours, when all leads are shown with green contours.***

Reason for relinquishment of PL 597-PL 597B is the non-alignment of the partnership onto VNG Norge's drill decision.
It is likely that distance to infrastructure, hence high CAPEX, related to the in-place resources played a important part in the partners' decision. Also, the presence of a dry well nearby in the same sandstone fairway is a challenging aspect to overcome, especially when seismic data is not optimal.

An potential way of lifting the confidence in the hydrocarbon potential, and increase resources would be to acquire new, purpose-designed seismic data. The Dønna Terrace is well known as a challenging area for seismic imaging, and the cost of such a survey is likely to be high.

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