Relinquishment Report PL839

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1 Introduction

1.1 License Owners

Aker BP ASA (23.835 %)

Equinor Energy AS (36.165 %)

Wintershall Dea Norge AS (28.0825 %)

PGNiG Upstream Norway AS (11.9175 %)

1.2 Award and Work Program

PL839 was awarded to the Skarv license group (BP Norge AS (operator) 23.8%, Statoil 36.2%, Dea 28.1%, PGNiG 11.9%) in 1Q 2016 as part of the APA 2015 Licensing Round. In 2016 BP Norge merged with Det Norske and became Aker BP, in 2018 Statoil changed name to Equinor Energy and in 2019 Dea merged with Wintershall and became Wintershall-Dea.

The production license has an area of 199 square kilometres and was awarded for an initial period of 7 years. The work program up to the drill or drop decision was to; 1) include an additional 70 km^2 of 3D seismic data in the common database, 2) reprocess and merge the 3D seismic data and perform geological and geophysical studies within the initial two years. A Drill or Drop decision was to be made before 05.02.2018.

A positive drill decision was taken on the KvitungenTumler exploration well (6507/5-8) which was drilled in the adjacent Skarv Unit (PL212). However, since the exploration target in the Lange Formation extended into PL839, it fulfilled the drill obligation for PL839 (OD 2018/18 Rsæ/EiJo). The exploration well was drilled with Deepsea Stavanger in the period 24.02.2018 to 27.03.2018. The well was dry with only traces of hydrocarbons.

A Plan for Development (PDO) was to be submitted before 05.02.2020.

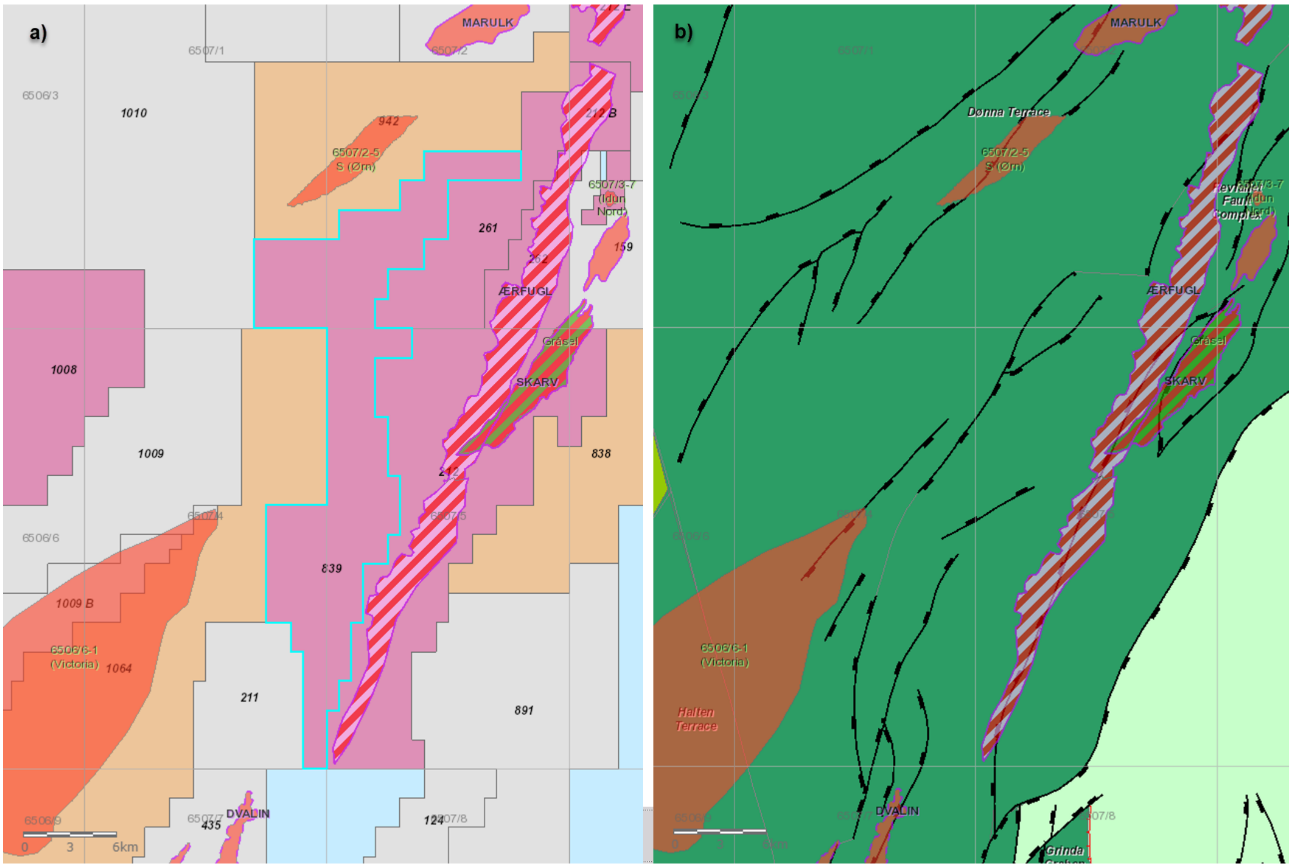


Fig. 1.1 PL839 license outline (a), fields, discoveries and structural elements (b).

1.3 Identified Prospectivity

The main evaluated prospects in the license are the Storkobbe Prospect, the KvitungenTumler Prospect (only partly in PL839) and the Nise Prospect, all identified as amplitude anomalies in the seismic data within the Lower Cretaceous Lange Fm (Fig. 1.2).

Storkobbe was identified as a combined structural and stratigraphic trap within the S3 sequence of Cenomanian age. It is on-lapping the regional Base Cenomanian sequence boundary, pinching out towards the east and south with a dip closure to the north and northwest.

The KvitungenTumler Prospect was identified as a strong amplitude anomaly within the S3 seismic sequence of Cenomanian age. It was interpreted as a turbidite sand deposited from the southeast and pinching out towards the Jurassic fault block that holds the Skarv Field. KvitungenTumler was considered as an attractive prospect to test and in 2018 the 6507/5-8 KvitungenTumler exploration well was drilled. The well was dry with only traces of hydrocarbons. This significantly increased the risk on the remaining prospectivity in the license, resulting in Storkobbe CoS (Chance of Success) being reduced to 7% and classified as lead.

The Nise Prospect was identified as a bright, soft amplitude (decrease in acoustic impedance) event associated with a local low in the Base Cretaceous surface. The anomaly has an elongated shape and lies within the S2 sequence of Aptian age. Deposition of the Hauterivian - Aptian sediments was controlled by topography of the Dønna Terrace, inherited after Later Jurassic rifting episodes and uplift. The uplifted and eroded Nordland Ridge is regarded as the most likely source for sediments, including the sands which are believed to be reservoir for the Nise Prospect. The Nise Prospect is a stratigraphic trap on a south-westerly dipping slope. Uncertainties in the exact mapping of the trap are related to the quality of the seismic data and limitations of the seismic resolution. Further description of the Nise Prospect can be found in 3.1 Nise Prospect.

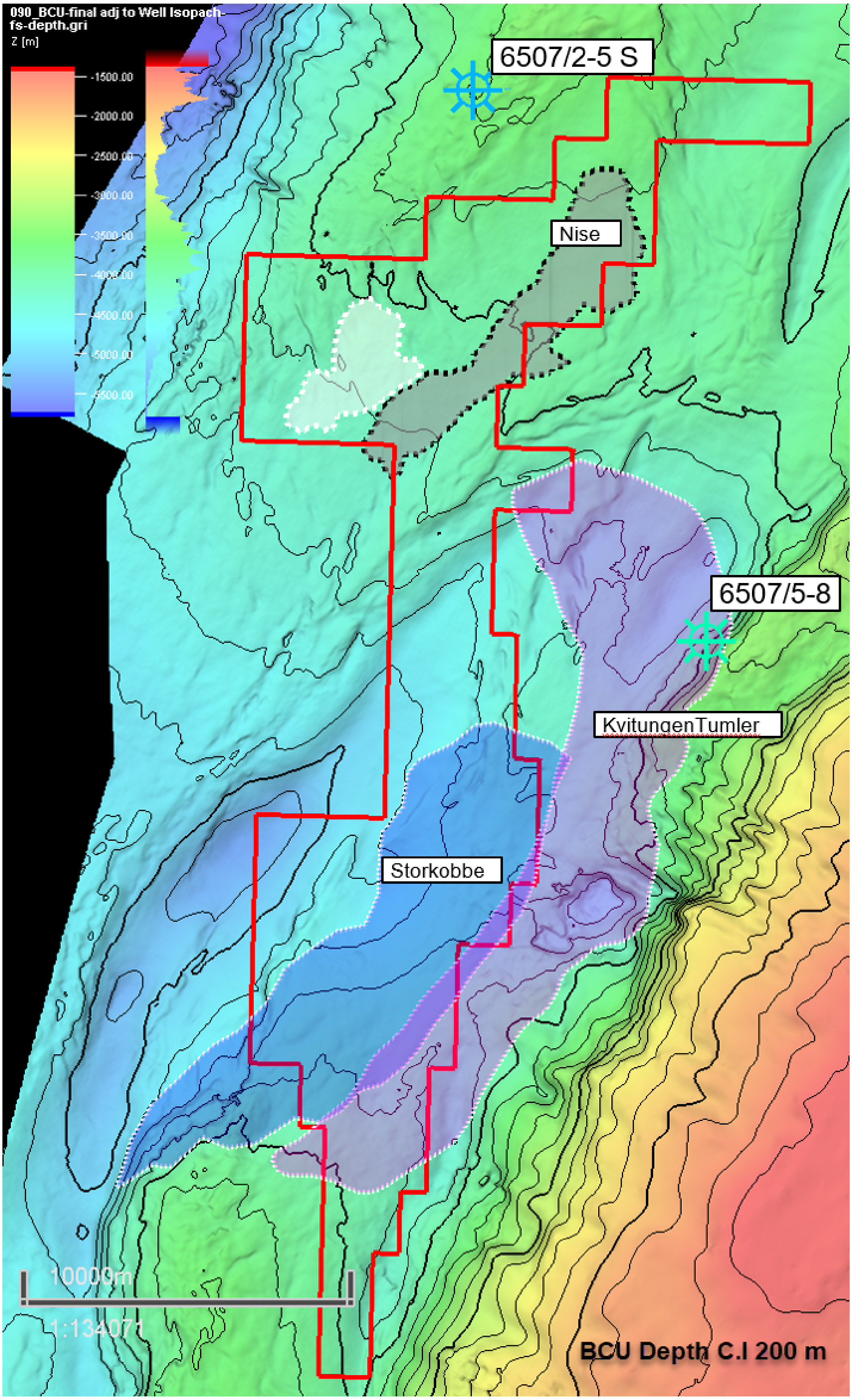


Fig. 1.2 Identified prospectivity. *Nise, KvitungenTumler and Storkobbe prospects outlined on a BCU depth map, in addition to the well testing the KvitungenTumler prospect (6507/5-8).*

2 Database

2.1 Seismic Database

The following 3D seismic surveys are included in the common database:

Table 2.1 Seismic Database

Seismic	Comments
HVG2011	PGS geostreamer data - parts included in PL839 common database
HVG2012	PGS geostreamer data - parts included in PL839 common database
BPR16	Post-stack reprocessing of HVG2011 and HVG2012 common database (as defined in 2016)
ABP17M01	PSDM reprocessing of HVG2011 and HVG2012 - parts included in PL839 common database
ABP17004	Isogrid seismic survey - whole survey included in PL839 common database

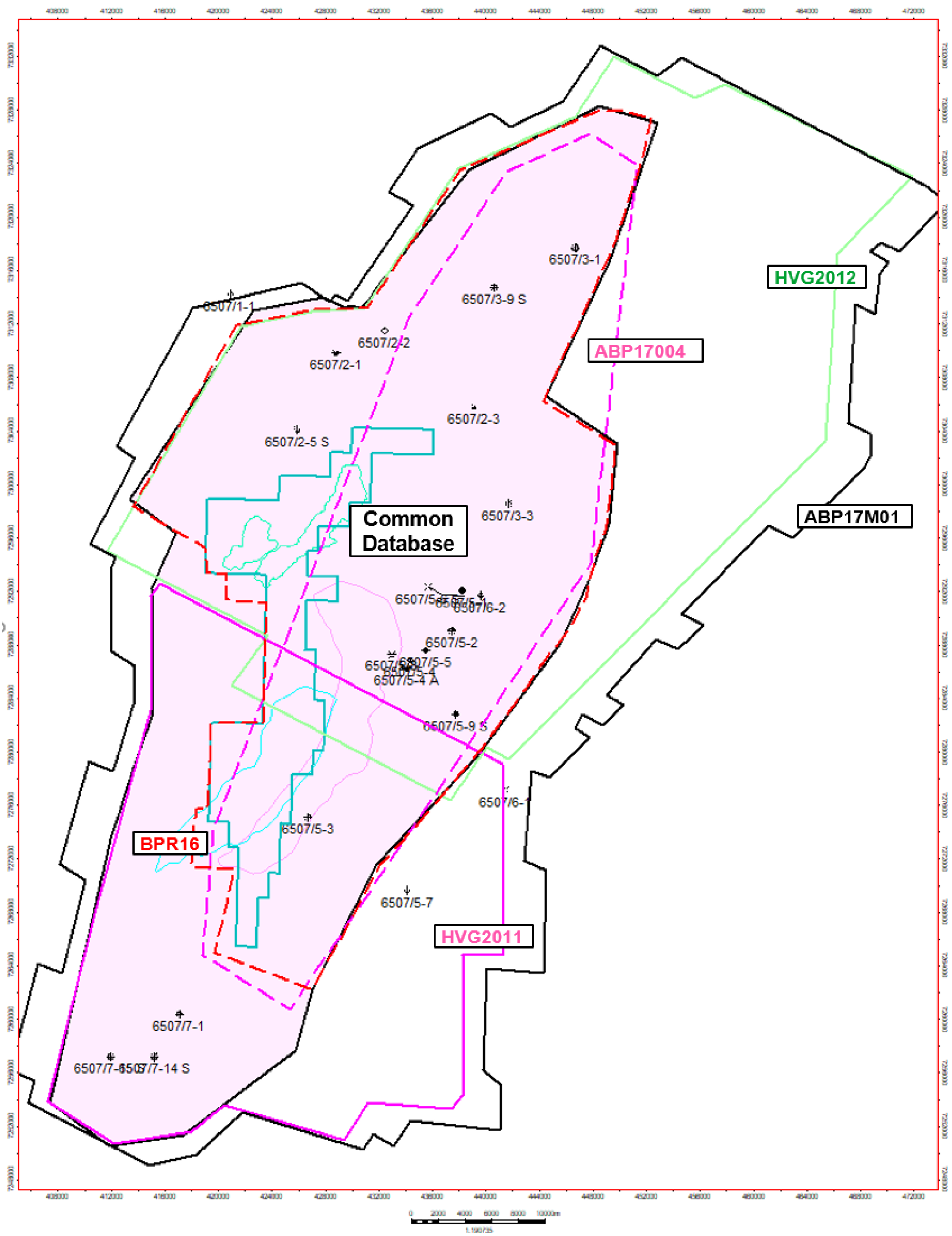


Fig. 2.1 Well and seismic data. *Wells and seismic in the area indicated on the map. The PL839 common database is shown in pink and includes, ABP17M01, BPR16, HVG2011, HVG2012 and ABP17004.*

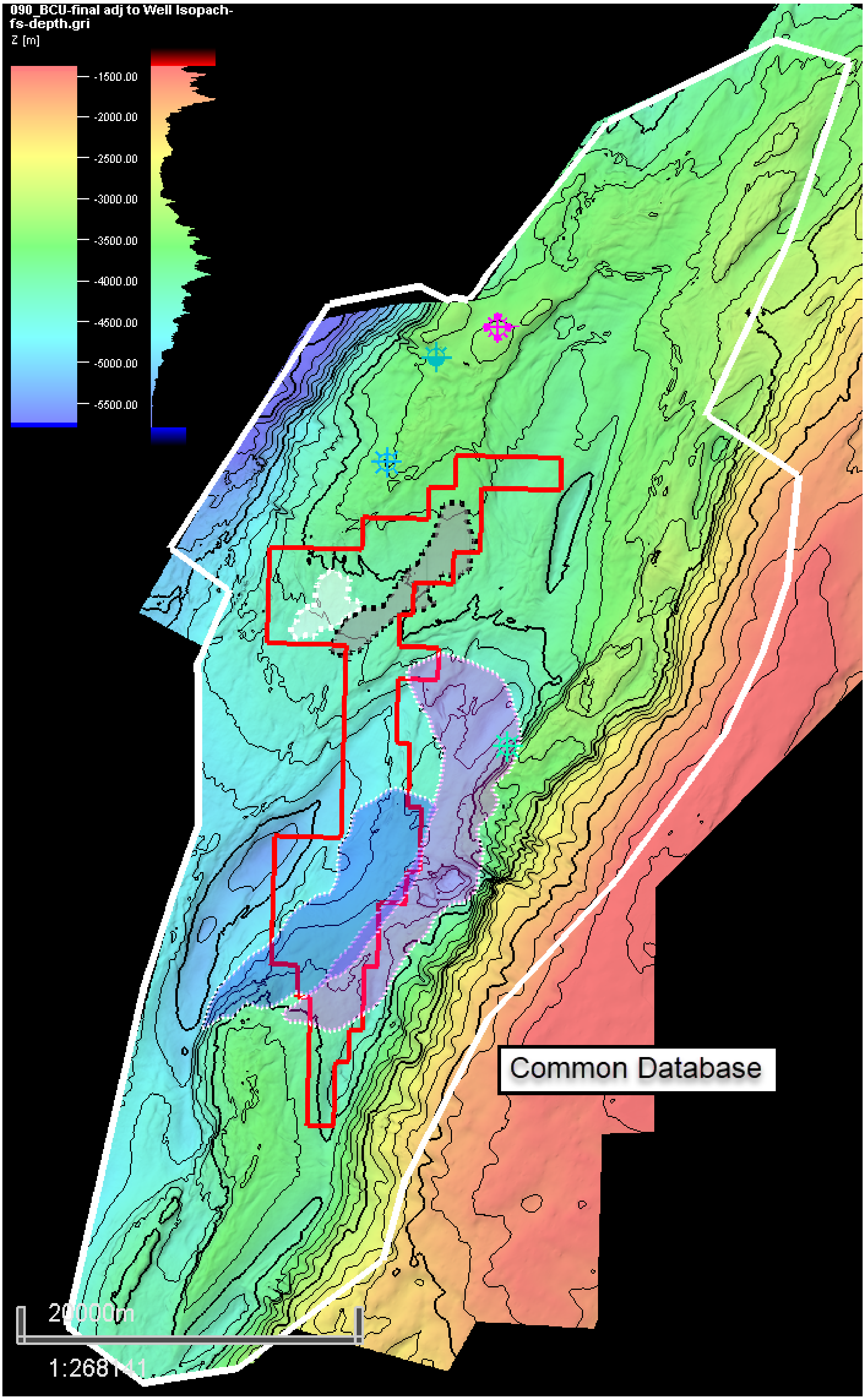


Fig. 2.2 Common seismic database. *Map with prospect and license outlines and common database indicated by the white polygon line*

2.1.1 Seismic reprocessing

The initial work program was to license, reprocess and merge 3D seismic data and perform geological and geophysical studies. This was fulfilled through the acquisition of the PGS geostreamer HVG2011 and HVG2012 data, in-house post-stack reprocessing of this data in 2016 (BRP16) and G&G screening work.

The common seismic database area was further extended in 2017, and the same post-stack reprocessing sequences was performed on the additional HVG data.

BPR16: The data was reprocessed through a post migration gather conditioning sequence to make it fit for AVO analysis, and the production of fluid and lithology volumes (BPR16 – comparable flow to BPR14, but also including merge of HVG2011 & HVG2012). The high quality data was then used for detailed evaluation of all the identified prospects.

A new PSDM reprocessing of the HVG field data (ABP17M01) was conducted by Western Geco in 2017-2018 and included full waveform inversion, velocity model building and tomography. This was included in the common database in 2019.

2.2 Well Data

The license well database consits of all Skarv wells and relinquished wells in the area. * = *key well*

Table 2.2 Well Database

Wells
6506/3-1*
6507/2-3*
6507/3-7*
6507/5-7
6507/5-B-3 H
6507/7-10
6506/6-1
6507/2-4*
6507/5-1*
6507/5-A-1 H
6507/5-B-10 H
6507/7-14 S*
6506/9-1
6507/3-1
6507/5-2*
6507/5-A-3 H
6507/6-1
6507/7-15 S
6507/1-1
6507/3-2
6507/5-3*
6507/5-A-4 H*
6507/6-2
6507/2-1*
6507/3-3
6507/5-4
6507/5-A-6 H
6507/7-1*
6507/2-2*
6507/3-4
6507/5-5*
6507/5-B-2 H
6507/7-12*
6507/12-2 S
6507/5-8 *

2.3 Special Studies

Seismic conditioning was performed on the common database ABP17M01 dataset (Fig. 2.2).

The angle stacks from the PSDM reprocessed ABP17M01 were further conditioned using AVARY, an AkerBP in-house software. The typical flow is frequency and phase matching between the angle cubes, de-noise and residual trim alignment, in addition to scaling. This was done before generating different products for AVO analysis. Different projection/attribute cubes were created and used in the screening process including: Gradient and Intercept, P- and S-impedance, and fluid factor.

3 Remaining Prospectivity

3.1 Nise Prospect

Nise is a medium sized, undrilled, amplitude driven prospect located mostly in the PL839 license west of the Skarv and Ærfugl fields (Fig. 3.1). The anomaly is located just above the Spekk and Lyr formations in the early Cretaceous S2 seismic sequence. The anomaly has been evaluated several times and was presented for the partners in May 2019, as a prospect with too high risk to reward ratio to be drillable.

Geological understanding

The current geological model for the Nise Prospect is turbiditic currents deposited from north/ northeast and the northern parts of the Nordland Ridge. An alternative geological model is turbidites deposited and then being reworked as contourites. Contourites are often seen as more muddy or silty deposits and therefore, such a depositional model is not direct evidence for sand.

Apparent overstepping lobes related to the Nise Prospect suggests that deposition is happening from the north. The "lobes" related to the Nise Prospect are lying in small depressions with similar geometries above the Spekk Fm. These can be seen on the seismic sections in Fig. 3.2. The main risk related to the Nise Prospect is the presence of sand. It is not clear from which direction the sand is deposited and there is no apparent amplitude conformance with depth. The prospect is highly amplitude driven and the seismic quality and seismic conditioning work performed is therefore important for the prospect evaluation. The performed geophysical work is described in the next sub chapter.

Volume and risk summary for the Nise Prospect is presented in Fig. 3.2.

Geophysical definition

- Seismic data uncertainty and implications for the Nise Prospect

Nise was defined based the MC3D-HVG2012 MBRP16 PSTM seismic survey in APA 2015. On this seismic data, Nise gave a class III AVO response, indicating a gas filled sand. On the newer PSDM reprocessed dataset, ABP17M01, Nise appeared as a weaker class IV response.

There has been issues/challenges with regards to the quality of the ABP17M01 seismic data when it comes to amplitude preservations for AVO work. When looking at older seismic versions of the dataset we see different processing results. Therefore an in-house processing task was performed to treat the ABP17M01 raw PSDM gathers with a process similar to what was earlier utilized on the a BPR16 in-house reprocessing.

The aim of the work was to check the possibility that the anomaly could be a class III AVO event and not a class IV, as earlier interpreted. A class III event could possibly give higher probabilities for sand within the expected porosity ranges at this depth. It was considered important to compare the anomaly seen in Nise with a regional low AI shale seen in the Alve area, and hence also compare Nise with drilled sands of the same Cretaceous sequence in the 6507/7-1 well (Dvalin).

After a thorough quality check of the seismic data, it is clear that there is a mismatch between the AVO behaviour in the newly reprocessed ABP17M01 dataset compared to predictions from wells inside the reprocessed area. This can be related to a too narrow Radon filter applied in the conditioning sequence, which might change the relative amplitude scaling along offset. As the offset scaling is very important for AVO investigation and the conditioning sequences applied to the data should be investigated further.

Conclusions

Several models for the amplitude anomaly in Nise have been evaluated:

- Turbidite deposits from the north-east
- Passive basin infill and onlap
- Erosion and re-deposition of Spekk
- Contourites deposited and reworked south-wards
- **Tuning and interference creating soft amplitudes in seismic**

Main conclusions and recommendation after internal evaluation and QA:

Geophysical work suggests that the Nise anomaly most likely is a shale interbedded with limestones or other hard layers. With the class IV AVO seen in the seismic data the Nise Prospect is likely to be interpreted as a low AI shale, as described above. Therefore we see high risk related to presence of reservoir and also the trap-definition of the prospect.

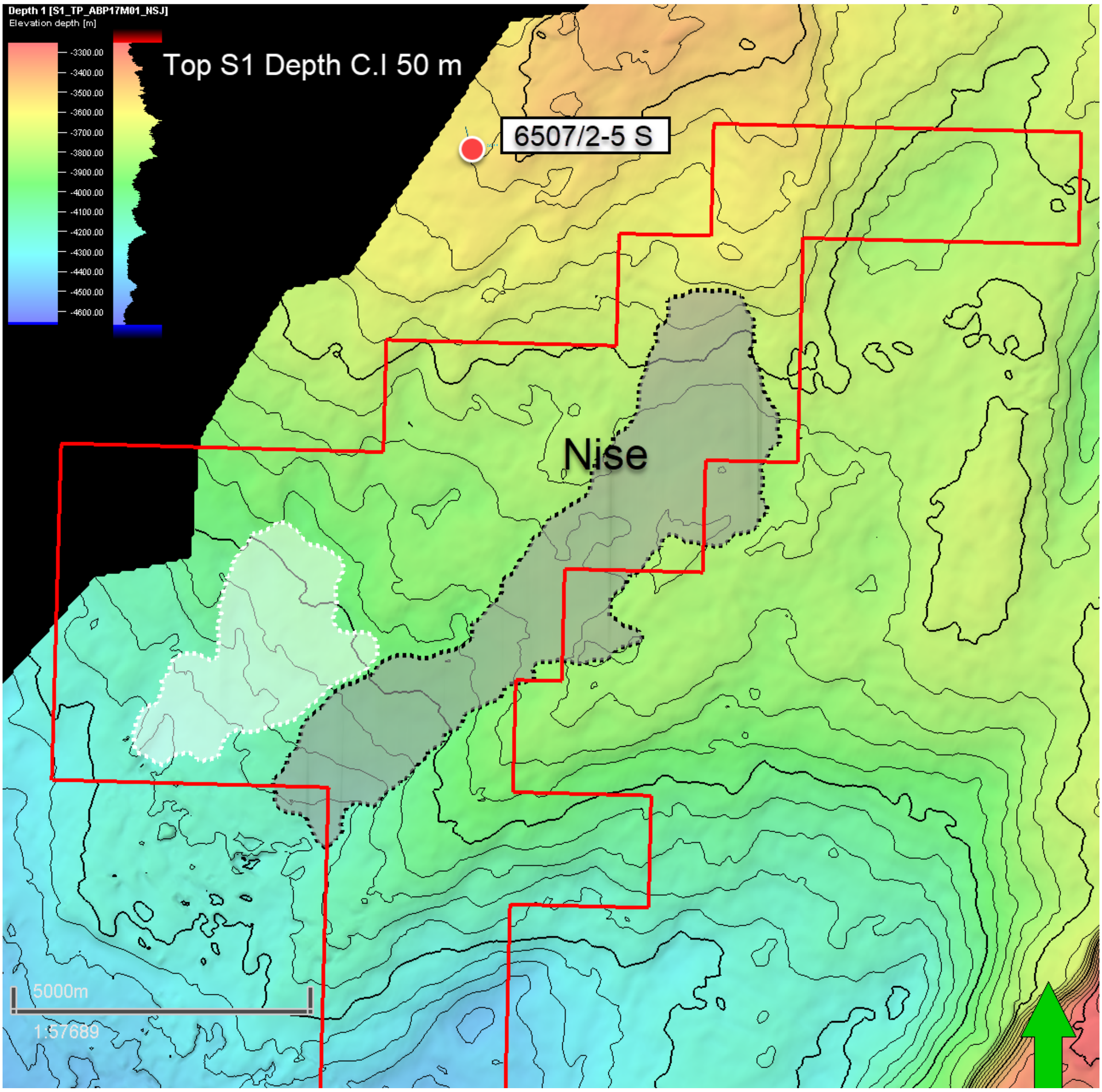


Fig. 3.1 Nise prospect depth map and outlines. *Nise depth map, license and prospect outlines.*

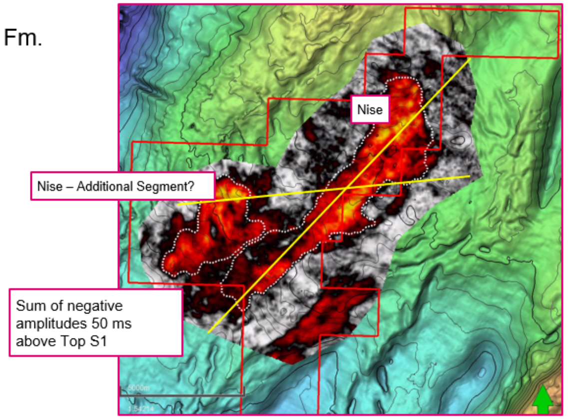
- **Trap:** Stratigraphic trap.
- **Seal:** Intra Lange mudstones.

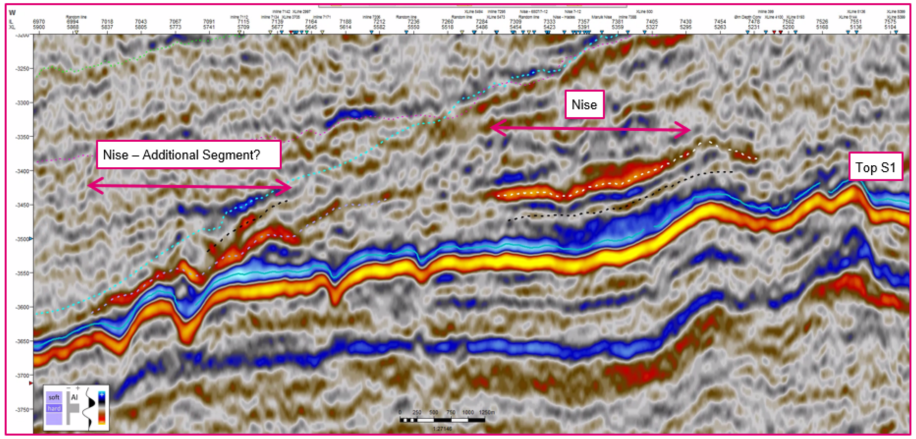
- **Reservoir Presence:** Lower Cretaceous deep water sst in lower S2 sequence.
- **Reservoir Deliverability:** Crest of the structure is at 3640 m. Poor ties to nearby wells. Sand in S1 in well 6507/7-12 (oil). Thin sandstones in Victoria (S2).

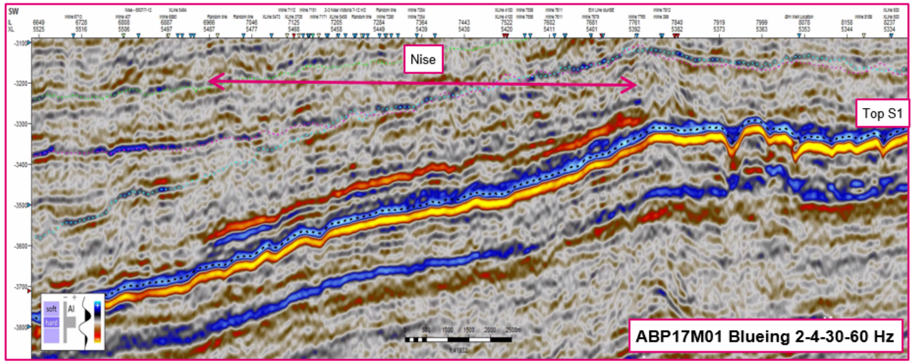
Source Presence: Spekk, Melke and Åre Fm.
Charge: Present day peak to late oil, vertical migration.

Recoverable Gas: 59 1e6 BOE

Main risk: Reservoir and Trap







Apex: 3640 m
OWC: 3790 – 3990 – 4190 m
Area: 7.5 – 17 - 28 km^2

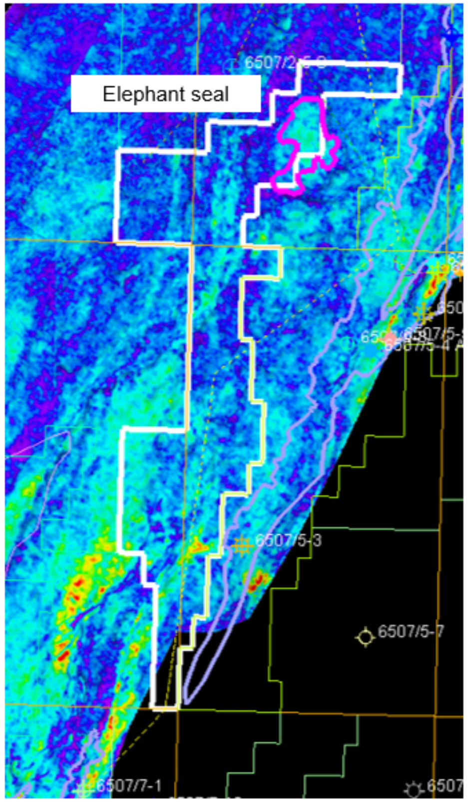
- Reservoir presence: 0.6
- Reservoir quality: 0.7
- Seal presence: 0.7
- Trap geometry: 0.6
- Source presence: 1.0
- Migration and timing: 1.0
- **COS: 18%**

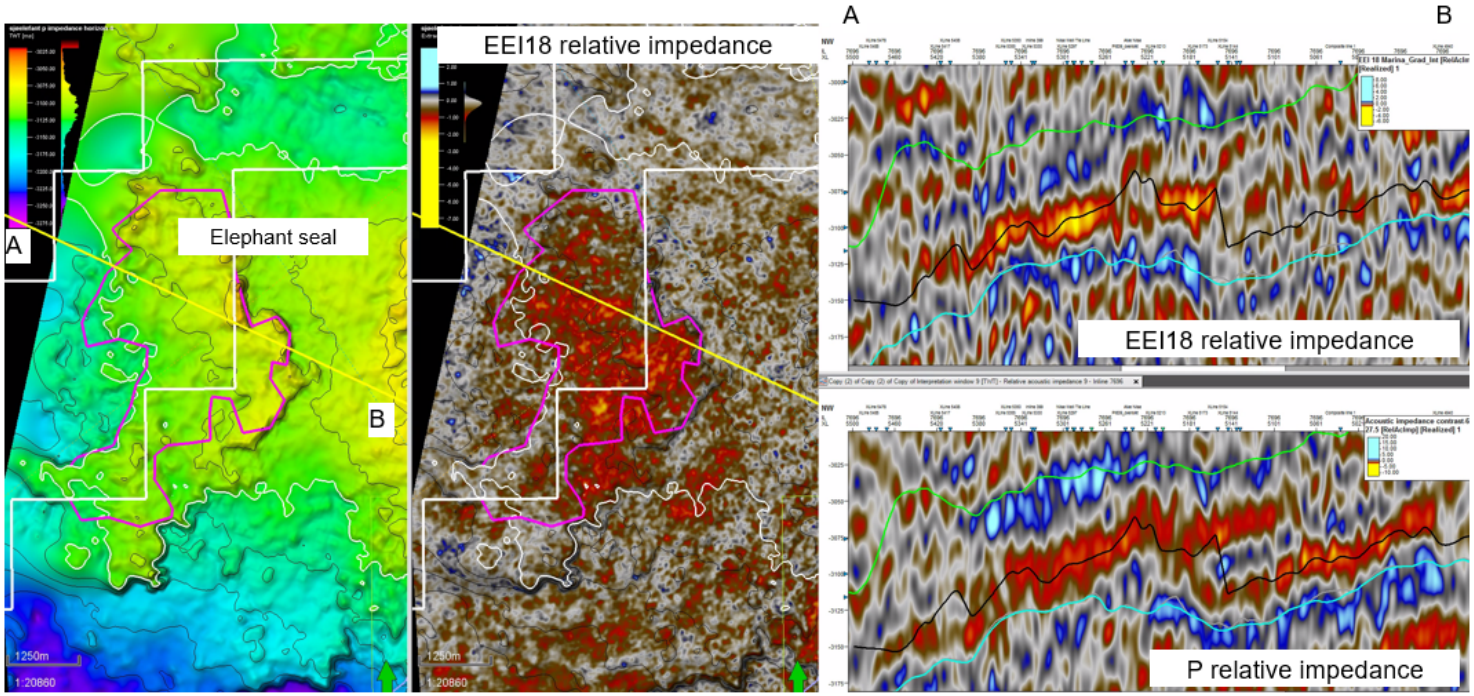
Rec. Resources	Mean	P90	P50	P10
Non Assoc. Gas (1e9 Sm3)	6.54	3.76	6.18	9.82
Condensate (1e6 Sm3)	2.86	1.45	2.62	4.55
Total (1e6 BOE)	**59.1**	**33.8**	**55.7**	**88.8**

Fig. 3.2 Nise prospect summary. *The Nise prospect showed on amplitude anomaly map and seismic sections. Volume and risk summary.*

3.2 Elephant Seal Lead

Elephant Seal is a small dip closure at the Cretaceous S4 level. The structure is defined by small faults to the east, north and south, and a dip closure to the west where a depth-conformant amplitude shut-off is observed. The lead is defined from an anomaly in P-reflectivity that is not recognised in the S-reflectivity, indicating that the anomaly could be related to a change in pore-fill (Fig. 3.3). The deposition system is not evident but may be a turbiditic system coming from the southwest with the Elephant Seal Lead being located in the distal part of the sand distribution system. There is a clear AVO anomaly related to this event. Although the volume potential is limited (~13 mill m^3 rec.), the Elephant Seal Lead is laterally positioned above the northern part of the deeper Nise Prospect (S2 level), allowing both levels to be tested by one well.





Left: The Elephant seal lead is located north in the PL839 license (minimum amplitudes 30 ms above S3 surface – far offset volume). **Right**: Depth and amplitude maps, correlation between depth contour and amplitude boundary for the prospect to the west. Seismic sections show a EEI rotation volume (upper) and a P-impedance volume (lower). On the relative P-(or intercept) impedance section we se that the unit is dipping upwards towards the east and it may consist of two soft layers. The EEI rotation shows that only the upper layer has a strong EEI deviation.

Fig. 3.3 Elephant Seal.

4 Conclusion

The result of the dry 6507/5-8 well increased the risk of the remaining Lange Fm prospectivity in the PL839 license and the Storkobbe Prospect was degraded to a high risk lead.

Extensive G&G work has been completed to understand the Nise anomaly and mature this to a drillable target, however the JV considers a drill decision on Nise to be pre-mature at this stage as there is still remaining uncertainties related to the AVO in the seismic data. Reservoir presence is considered a main uncertainty. Experience from detailed AVO analyses in the area shows that the acoustic properties for the shales above and below the Lange sands vary considerably. This makes the AVO work in the area complicated and more prospect specific processing is required. This was not possible within the remaining time frame of the license before the BoK decision.

No discoveries have been made in the license area and hence the JV cannot fulfil a BoK commitment. As the JV is not ready to commit to a well, the decision was made to relinquish the licensed area.

5 References

- APA 2015 Application