Relinquishment Report

Jaeren High, Central North Sea

Licence: P.2004

Blocks: 22/10b, 22/15c, 23/6 and 23/11b

Date: November 2014

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1 Licence information

Licence Number: P.2004
Licence Round: 27th Seaward Licencing Round
Licence Type: Traditional
Block Numbers: 22/10b, 22/15c, 23/6 and 23/11b (Figure 1)

2 Licence synopsis

Licence status: End of drill-or-drop period
Timing: The licence was awarded to Centrica Resources Limited and its partners as part of the 27th Seaward Licencing Round with a start date of 1st January 2013, a drill-or-drop period of two years ending on 1st January 2015 and an initial term of four years ending on 1st January 2017
Participants: Centrica Resources Limited (40%, operator), E.On E&P UK Limited (30%) and Maersk Oil North Sea UK Limited (30%)
Work obligations: Firm commitments to obtain 275sqkm of 3D seismic data processed to PSTM and carry out geochemical data gathering and modelling. Drill-or-drop commitment to either drill a well targeting the Upper Jurassic Fulmar Formation or withdraw from the licence, according to the timings above.
Licence extensions: No extensions agreed

The main focus of the licence application was prospectivity within the Upper Jurassic, specifically an extension of the sub-BCU pod-interpod play, proven at Brynhild, northwards over the Jaeren High into areas previously thought to be unprospective (maturity and migration ineffective). This was achieved through mapping on PGS MegaSurvey and CGG GeoSpec TerraCube seismic data, regional geochemical analysis and constructing a quick-look basin model using Schlumberger’s PSQL software. Four Upper Jurassic Fulmar Formation prospects/leads were identified: Esk, Clova, Menmuir and Lethnot, with Esk considered as the primary prospect (Figure 2). Volumes for Esk at the time of application were reported as 1.4-6.8-102mmbbls (P90-P50-P10) with a geological chance of success of 31%. While the geochemical modelling studies showed that charging of the Upper Jurassic prospects was possible, the maturity of the Kimmeridge Clay Formation source rock and migration remained key risks. In particular, the source rock maturity over this part of the Jaeren High appeared to be marginal and the exact mechanism for charging the traps was uncertain, with both long-distance migration along convoluted pathways (from deep grabens to the west) and local source kitchens invoked to explain known accumulations at sub-BCU level elsewhere on the high.

The pinchout of Paleocene sands onto the Jaeren High, as an extension of the Everest play to the west, was considered as secondary prospectivity on the licence. Three Maureen Formation prospects were identified: Memus, Prosen and Isla (Figure 2), all of which were volumetrically small (P50 volumes between 1.1 and 3.4mmboe). No undeveloped discoveries are present on the acreage.
3 Work programme summary

The agreed work programme comprised firm commitments to obtain 275sqkm of 3D seismic data processed to PreSTM and carry out geochemical data gathering and modelling; and a drill-or-drop obligation either to drill a well to 3050m or Top Fulmar, whichever is the shallower, or withdraw from the licence. Both firm commitments on the licence were met within the initial drill-or-drop period; the partnership purchased, modelled, interpreted and depth converted 1594sqkm of PGS MegaSurvey Plus 3D seismic data and undertook a geochemical data collection and basin modelling study with Integrated Geochemical Interpretation (IGI) to address the maturity and migration risks. In addition, a rock physics study of the Paleocene and Upper Jurassic intervals was carried out with Ikon Science and a petrophysical evaluation of all potential reservoir intervals was completed by AGR TRACS. At the end of the drill-or-drop period a decision was taken to withdraw from the licence without drilling a well.

The new seismic dataset provided a significant uplift in data quality over the PGS MegaSurvey data used at the time of application through improved imaging of pod-interpod boundaries and internal structure of the interpods themselves (Figure 3). In general this has improved the mapping of the Kimmeridge Clay Formation source rock and Fulmar Formation reservoir over the Jaeren High, although the lack of well control within the prospect interpods still results in a degree of uncertainty in those areas.

While no new wells were drilled on the licence, Lundin drilled well 7/4-3 on the Carlsberg prospect in April 2013 targeting Triassic Skagerrak sands on the crest of a pod immediately to the east of the licenced acreage (Figure 4 and Figure 6). The well failed to encounter any Skagerrak sands and the secondary objectives (Paleocene and Upper Cretaceous Ekofisk and Tor chalk) were water-bearing with the no indications of hydrocarbons.

4 Database

The 1594sqkm of PGS MegaSurvey Plus 3D seismic data, purchased as part of the firm work programme, formed the primary dataset over the acreage, replacing the PGS MegaSurvey data used in the pre-bid evaluation (Figure 4). A variety of other seismic surveys were required in order to map the prospectivity into the Norwegian sector and to create regional horizons over an AOI appropriate for the IGI basin modelling study. The CGG GeoSpec TerraCube Regrid Norway survey was used to extend the Jaeren High interpod play east of the MegaSurvey Plus data limit and a number of 2D lines were used to cover the data gap in Norwegian block 7/4. To the west of the purchase area, a combination of the original PGS MegaSurvey data, existing PGS MegaSurvey Plus entitlement and CGG Veritas Cornerstone data was used for the regional interpretation due to a number of holes in the PGS sourced data.

Key wells utilised in the evaluation of the prospectivity and in the depth conversion are shown on Figure 2 and Figure 4.
5 Prospectivity update

Since licence award the work programme has focussed on de-risking the sub-BCU play. At this level the Jaeren High is characterised by well-defined salt withdrawal pod-interpod structures with the potential for stratigraphic traps where shallow marine sands of Upper Jurassic Formation age onlap/truncate against Triassic Smith Bank shale pods. Top seal is provided by the Kimmeridge Clay Formation, which may also act as a local source, charging the traps through downwards migration. To the southeast, the discovery and current development of the Brynhild field (formerly Nemo) in the Norwegian sector of the Jaeren High provides a direct analogue for the Upper Jurassic prospects on this licence.

A 2D seismic modelling study has been undertaken to better understand the geometrical relationships between the Cromer Knoll Group, Upper Jurassic strata and Triassic Smith Bank Formation at the pod/interpod boundaries. Matching the new PGS MegaSurvey Plus data with the 2D synthetic seismic response at Brynhild and Esk has demonstrated that the Fulmar Formation and Upper Jurassic units truncate sharply against the pod walls, rather than onlapping the crests, and this geometric model has been taken forward into the seismic interpretation (Figure 5).

Re-mapping of the licenced blocks on the new seismic data and subsequent depth conversion has shown that Esk and Clova are the only valid Upper Jurassic structures (Figure 6, Figure 7 and Figure 8). Changes in the mapped areal extent of Esk to the northwest and northeast have resulted in a decrease in trap size of the prospect since licence application, whereas a thicker mapped Fulmar interval at Clova has increased the prospect’s trap size slightly. Unlike the previous interpretation, the new mapping does not map a continuous migration pathway through the Fulmar sands from the deep grabens (East Central Graben and/or Witch Ground Graben) up onto the Jaeren High and into the prospect interpods, meaning that the prospects must rely on a local charge model rather than long-distance migration from the basins (Figure 6).

Evidence for a local charge model has been provided by the geochemical analysis of oils and hydrocarbon stains on the Jaeren High, which strongly indicate that locally mature Kimmeridge Clay Formation source rock has charged Brynhild and other interpods south of Esk and Clova. The geochemical data collection and modelling study has also demonstrated that the source rock within the Esk and Clova interpods is likely to have reached oil maturity during the Eocene to present. Despite the work programme reducing the risk on the source, the modelled volumes of oil available to fill the traps at Esk and Clova were not as large as initially hoped and there is a considerable risk that the prospects will be underfilled. There is also a risk on the integrity of the Triassic pods as lateral seals, given that a significant thickness of Triassic sand was encountered at the crest of pod 7/1-1 to the east of Esk.

Recoverable volumes at Esk have been calculated probabilistically by combining three different structural scenarios (Figure 7) with a distribution for the amount of charge available. Volumes for Clova were calculated in the same way, although only one structural case was considered. The resulting volumes were modest for both prospects (Table 1).

Re-mapping of the Paleocene play confirmed Memus as the only valid structure and that the volumes remained small (Table 1). The prospect outline remains the same as in Figure 2.
6 Further technical work undertaken

An AVO modelling study by Ikon Science concluded that, although a class I/IIp response should be observed at the top reservoir in the Paleocene and a class IV response is commonly associated with the top Fulmar Formation in synthetic gathers, AVO has limited diagnostic potential on the Jaeren High due to the insensitivity of the gradient to reservoir fluid fill. Similarly, inversion products within the Paleocene and Fulmar were inconclusive when it came to distinguishing between fluids and lithology. On the basis of these findings, no further AVO work was completed.

Amplitude mapping and focussed spectral decomposition of the Paleocene has shown no evidence of missed channels over the prospects in the licence area and indicated that the main sand fairway is outside the licence area (to the west) both within the Forties and Maureen intervals. Based on this observation, the presence of an effective reservoir at Memus is a significant risk.

A regional petrophysical evaluation by AGR TRACS has yielded a full set of reservoir parameters for the Paleocene and Upper Jurassic intervals on the Jaeren High.

7 Resource and risk summary

Table 1 summarises the recoverable resources and geological chance of success associated with each of the remaining prospects on the licence.

Table 1 Recoverable resources associated with the remaining undrilled prospectivity on licence P.2004. Note that Low-Central-High volumes equate to P90-P50-P10.

<table>
<thead>
<tr>
<th>Prospect / Lead / Discovery Name</th>
<th>Stratigraphic Level</th>
<th>Unrisked recoverable resources</th>
<th>Geological Chance of Success %</th>
<th>Risked P50 MMboe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oil MMbbls</td>
<td>Gas BCF</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>Central</td>
<td>High</td>
</tr>
<tr>
<td>Esk</td>
<td>P Upper Jurassic</td>
<td>4.4</td>
<td>17.1</td>
<td>55.8</td>
</tr>
<tr>
<td>Clova</td>
<td>P Upper Jurassic</td>
<td>16.7</td>
<td>44.6</td>
<td>84.1</td>
</tr>
<tr>
<td>Memus</td>
<td>P Paleocene</td>
<td>7</td>
<td>20</td>
<td>52</td>
</tr>
</tbody>
</table>

8 Conclusions

Re-mapping blocks 22/10b, 22/15c, 23/6 and 23/11b on new, improved seismic data and carrying out a number of detailed regional studies has helped de-risk the Upper Jurassic prospects, Esk and Clova, but has not improved the volumes significantly. A decision was therefore taken to relinquish the licence due to the modest sizes of the remaining prospects.

9 Clearance

Centrica Resources Limited confirms that DECC is free to publish this report and that all third party ownership rights on any contained data and/or interpretations herein have been cleared for publication purposes.
10 Maps and figures

Seismic figures reproduced in this section are based on PGS MegaSurvey and MegaSurvey Plus data supplied courtesy of Petroleum Geo-Services and TerraCube PSTM data supplied courtesy of Robertson GeoSpec International Limited.

![Map of blocks 22/10b, 22/15c, 23/6 and 23/11b in the Central North Sea](image)

**Figure 1** Location of blocks 22/10b, 22/15c, 23/6 and 23/11b in the Central North Sea
Figure 2 Prospects and leads identified on the licenced acreage at the time of application. Upper Jurassic prospects and leads are shown in orange; Paleocene prospects and leads are shown in green.
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