205/16c (P2041) Relinquishment Report

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Licence Information

Licence Number: P2041
Licence Round: 27th
Licence Type: Traditional
Block Number: 205/16c (Figure 1)

Equity: BP 50%, Shell 50%

Permission to publish this report in full is granted by BP and its P2041 co-venturer, Shell. The seismic data over the licence was acquired on a proprietary basis and is also cleared for publication.

Figure 1: P2041 licence map
Licence Synopsis

Block 205/16b was applied for by BP and Shell in the 27th Round in April 2012. Upon award in October 2012 the block was split and 205/16c was awarded to BP and Shell as Licence P2041. This was a traditional seaward production licence with a four-year initial term that commenced on 1st January 2013. Licence expiry is due on 31st December 2016, but the Joint Venture (JV) decided to relinquish the licence nearly three years into the initial term. Licence relinquishment has been confirmed by OGA, effective 30th November 2015.

The work programme for P2041 was as follows:

Firm commitments:
The Licensee shall reprocess 205 km$^2$ of 3D seismic data.

Drill-or-drop:
The Licensee shall either:
   (a) Drill one well to 2000m or Base Tertiary, whichever is the shallower, or;
   (b) Elect to allow the licence to automatically cease and determine pursuant to Clauses 3 and 6 [of the licence agreement].

The main prospectivity identified at the time of application was a presumed Palaeocene T31 turbidite sandstone reservoir system to the east of similar systems in the Schiehallion and Loyal Fields. Amplitude maps (far offset maximum trough) at the time showed an anomaly giving the appearance of a meandering channel similar to the “Snake” channel on Schiehallion (Figure 2). This prospect, which also lies partly in Block 205/16a, was referred to as Ghlo Core.

Figure 2: Identification of Ghlo Prospects in 2012. 1993 seismic data re-processed in 1999. Far offset maximum trough amplitude.
A further amplitude anomaly to the east at the same stratigraphic level was referred to as the Ghlo East Lead (Figure 2). Additional prospectivity was considered in the Lower Tertiary and Mesozoic, but no leads were identified at the time of application.

This prospectivity was addressed during the licence period and is described in this report.

**Work Programme Summary and Database**

The main aims of the work programme were to:

- Progress the Ghlo Core Prospect to a drill-ready status
- Further describe the opportunity of the Ghlo East Lead
- Identify and mature additional Tertiary prospectivity in the licence

In order to do this the JV’s preference was to acquire new broadband 3D seismic in 205/16c as an extension of the 2013 Foinaven-Schiehallion-Loyal 4D survey. However, the JV were unable to offer this as a licence commitment due to potential operational constraints which put the Ghlo extension lower down the acquisition priority list than the 4D data over Schiehallion and Loyal. Thus, the JV committed to re-processing the 1993 3D seismic survey that forms the only previous coverage of the whole of the Ghlo area. This 1993 survey over Ghlo was last re-processed in 1999.

In the end, there were no issues with the seismic acquisition operation and the new survey was completed over the Ghlo area in 2Q 2013 (Figure 3). This is known as the FLAGS survey (Foinaven, Loyal, Alligin, Ghlo, Schiehallion). In addition, the 1993 seismic data over Ghlo was re-processed to examine the possibility of a 4D response that might suggest hydrocarbon presence (due to potential depletion from Schiehallion Field). Thus, the firm licence commitment was met.
The subsurface evaluation consisted of geophysical and geological interpretation and petrophysical analysis of relevant offset wells, integrated with the description of the Schiehallion and Loyal Fields. In addition a significant seismic analysis project was undertaken to understand the likely lithology and fluid content of the Ghlo leads. This consisted of fluid substitution, modelling and analysis of gathers to determine if AVO effects were predictable and observable.

Key data used in the evaluation are:
- 2013 3D seismic survey (Figure 3)
- 1993 3D seismic survey
- 205/16-1 well (Figure 2)
- 205/17a-1 well (Figure 2)
- Schiehallion and Loyal Field wells

**Prospectivity Update**

**2012 Application**

At the time of application (May 2012), the co-venturers believed that prospectivity in the area was restricted to the Tertiary section, which was subdivided into two plays:

- Late Palaeocene play (T31 through T34 turbidite sands) containing the Ghlo Core and East Leads.
- Early Palaeocene play (T10 through T28) with no leads at the time of application.

In addition, no leads were identified in the Mesozoic section. Thus, the application was focussed on the T31 Ghlo Core and East Leads. These leads were thought to be T31 in age due to seismic interpretation of a prominent trough event from the Schiehallion area through Ghlo to the nearest offset wells 205/16-1 and 205/17a-1. Well 205/16-1 has a 35 m gross T31 interval with 9 m of net sand and well 205/17a-1 has a 36 m gross T31 interval with 13 m of net sand. Both are water-wet. The prospects were mapped on the best seismic data available at the time, which was acquired in 1993 and re-processed in 1999. However, this 1993 data had a 9 Hz low cut filter applied at the time of acquisition and this has significantly affected the resolution of the data. Thus new seismic acquisition was recommended.

The Ghlo Core Lead was recognised as a combination stratigraphic/structural trap defined by the seismic amplitude anomaly at T31 reservoir level. Amplitudes suggest channel edges on two sides of the trap and possible conformance with the Schiehallion OWC down-dip. The up-dip portion of the trap was poorly imaged due to the presence of a gas chimney that disrupts the seismic data.

Charge access was also seen as a key risk as the southern bounding fault of Loyal may be a migration end point. Elsewhere on Schiehallion, some channels at T31 and T34 level are known to be water-wet, suggesting that faults have acted as barriers to migration.

In 2012, estimates of recoverable volumes for Ghlo Core were 19-30-37 mmboe (P90-Mean-P10). Chance of success was rated at 24% with charge access and trap being the key risks.

The Ghlo East Lead was less well defined on the available 3D seismic data. Amplitudes associated with this lead were seen to be areally extensive, but lacked conformance with structure and were broken up by faults. Recoverable volumes were estimated at 44-87-91 mmboe (P90-Mean-P10) with a chance of success of 18%. Key risks were thought to be trap presence and charge access.
Current View of Prospectivity

New seismic data was acquired in 2013 and processed through to 2Q 2014. This was followed by seismic interpretation and analysis through to 1Q 2015. Initial steps were to re-evaluate the biostratigraphy of the key offset wells 205/16-1 and 205/17a-1 to confirm the well to seismic tie and enable seismic interpretation. This work confirmed that the two thin sands encountered in the wells are T31 in age and lie above a mudstone-dominated sequence (T28 down to T10). The synthetic seismogram for 205/16-1 suggests that the prominent trough event mapped across the area represents Top T31 (Figure 4). However, the quality of the logs is poor and there is no density log meaning that confidence in the well tie is poor. The synthetic seismogram for well 205/17a-1 is better due to better sands and logs. This shows more conclusively that the prominent seismic event is below the T31 sands at about Top T28 (Figure 4). The sands themselves appear to be below seismic resolution. The seismic event is now interpreted as Top T28.

205/16-1

205/16-1 (T31):
Gross: 36 m  Net: 9 m
Por: ~20%

205/17a-1

205/17a-1 (T31):
Gross: 36m  Net: 13 m
Por: 26%

Logs are poor quality and there is no density log. Sand is poor quality. Well to seismic tie is not good.

Logs are good quality. Sand is good quality. Well to seismic tie is good.

Figure 4: Synthetic seismograms of key offset wells 205/16-1 and 205/17a-1.

This new interpretation for the key seismic event is confirmed by a close examination of the 2013 seismic data, especially the coloured inversion data (Figures 5a and 5b). This demonstrates that the main T31 channels are confined to the Schiehallion/Loyal area and that the Ghlo leads are T28 in age. It is possible that T31 sands exist in the Ghlo area, but they are likely to be below seismic resolution, as seen at 205/17a-1 mentioned above.
An amplitude extraction below the T28 seismic event shows that the Ghlo Core anomaly no longer appears to conform with depth structure (Figure 6). There does, however, appear to be amplitude switch off at a fault. The Ghlo East amplitude anomaly now has no clear outline and is heavily broken by faults. It was discounted as a lead at this stage and not worked any further.
A key aspect of the Ghlo Core Prospect is the definition of the up-dip portion of the trap. It was hoped that the new seismic data would improve the imaging in this area, but this turned out not to be the case (Figure 7). The gas chimney in this area continues to make seismic imaging difficult. It is unclear where gas is escaping from, but it appears to have made its way through to just below the sea bed (a possible palaeo-pock mark). The lack of definition here is a key risk for the prospect.
Further Technical Work Undertaken

Work was conducted to examine the AVO response at Ghlo Core. Fluid substitution at nearby wells indicates that, if hydrocarbons are present, they should be visible in the seismic as a Class 2, 2p or 3 AVO response (Figure 8). Analysis of the CDP gathers at Ghlo Core indicate that a Class 4 shale response is present (Figure 9). 4D analysis shows no clear response at Ghlo Core. Spectral decomposition does not show up any channel-like geometries that might indicate a reservoir at Ghlo Core.

Figure 8: Fluid substitution and near-far offset comparison for T31 and T28 sands in Schiehallion well 204/20a-F01
Seismic attribute work strongly suggests that no reservoirs are present at Ghlo Core. However, reservoir depositional maps were updated using nearby wells and the new seismic information to better understand the reservoir distribution in the area. These show that T28 sands are unlikely to be deposited in the Ghlo area and the T31 may only have minor sand fairways in Block 205/16c (Figures 10 and 11). Both systems are confined to a N-S (T28) or NW-SE (T31) orientation through the Schiehallion/Loyal Fields to the west, with no evidence of reservoirs in Block 205/16c. It appears that a palaeo-high exists in the Palaeocene to the east of Schiehallion. Reservoir presence is seen as a fatal flaw for Ghlo Core, which is now not considered to be a viable prospect.
Resources and risks for Ghlo Core are presented below.
Additional Prospectivity

Having written off both Ghlo Core and Ghlo East Leads, an examination was made of other potential prospectivity in the licence. This focussed on the following levels:

- **Base Balder:** Structures created by Early Eocene uplift and erosion could trap hydrocarbons
- **T25:** A producing reservoir at Schiehallion and Foinaven
- **T10:** Same age as the Marjun discovery 40 km west of Schiehallion
- **K50:** Albian. Close to the top of Lower Cretaceous sand-prone intervals in the West of Shetland area
- **Base Cretaceous:** Defines Early Cretaceous and Jurassic potential

**Base Balder:**

The Base Balder is an erosional surface created by a dendritic drainage system during a period of rapid regional uplift. Hydrocarbons have been encountered at this level in nearby well 204/25a-8, but were biodegraded. The depth map and seismic example show that there are no significant closures at this level (Figures 12 and 13). Thus no leads have been identified at Base Balder.

![Base Balder Depth](image)

Figures 12: Base Balder depth map (metres)
Figure 13: Seismic example showing no significant closures at Base Balder level.

**T25 and T10:**

The T25 is represented by deep marine turbidite channel sands in the Schiehallion area. The T10 is a system of basin floor fans that are widespread between Schiehallion and Marjun. The Top T25 and Top T10 seismic events were mapped across the area, but no significant closures have been identified (Figure 14). Amplitude maps do not suggest any stratigraphic traps. 205/16c lies to the east of the known Schiehallion sand fairways and wells suggest reservoirs of this age are absent (Figure 15). No leads are identified at these levels.
Figure 14: Top T25 depth map (metres)

Figure 15: T25/T10 well correlation
Top Albian and Base Cretaceous Unconformity:

A tilted fault block has been identified at Top Albian (K50) and Base Cretaceous Unconformity (BCU) levels, which straddles Blocks 205/16c and 205/16b (Figures 16 and 17). This lead has been called Ghlo Deep. The K50 seismic event is a prominent marker that can be tied to a limestone in well 205/16-1, the only well that tests the deep stratigraphy in the immediate licence area (Figure 17). Well 205/16-1 suggests that if any sands are present in the Lower Cretaceous they are very thin (about 4 m sand encountered in the well). The Lower Cretaceous lies directly on metamorphic basement at the well. It is possible that the seismic event interpreted as Base Cretaceous at the well becomes a Base Jurassic event at the prospect, such that a thin section of Late Jurassic Rona Fm sands are preserved (as seen in nearby well 205/22-1A).

Figure 16: Depth map (metres) at Top K50 and Base Cretaceous Unconformity

Figure 17: Ghlo Deep seismic example
The Ghlo Deep Lead lies at about 5000 m TVDSS (4500 m BML). At such depths, reservoir quality may become an issue. There are no clear porosity trends in offset wells, but values in the range 10-17% may be possible, especially if overpressuring occurs.

Volumes for the Ghlo Deep Lead are presented below.

**Resource and Risk Summary**

**Ghlo Core:**

Whilst seismic analysis shows that significant reservoir presence at Ghlo Core is very unlikely, volumes have been estimated and risked accordingly. A range of gross rock volume (GRV) numbers were derived to represent high, mid and low cases. A wide range of net to gross values was used given the uncertainty in reservoir presence.

Volumetric parameters:

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<th>Min</th>
<th>ML</th>
<th>Max</th>
<th>Units</th>
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<tr>
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<td>131155500</td>
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<td>Area</td>
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<tr>
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<tr>
<td>Porosity</td>
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<td>0.25</td>
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<tr>
<td>Hydrocarbon Saturation</td>
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<td>GOR</td>
<td>130</td>
<td>340</td>
<td>550</td>
<td>scf/stb</td>
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<td>Recovery Factor Oil</td>
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<td>0.3</td>
<td>0.4</td>
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</table>

Volume range for Ghlo Core Prospect is 9-26-47 mmboe (P90-Mean-P10). This is similar to the range at the time of licence application.

Exploration risk elements:

- **Trap:** 40%
- **Seal capacity:** 70%
- **Reservoir presence:** 10%
- **Reservoir deliverability:** 55%
- **Source presence:** 100%
- **Charge access:** 70%

Overall chance of success: 1%

Reservoir presence is seen as a fatal flaw, with considerable additional risk on trap due to the poor updip imaging at a gas chimney. At this degree of risk, the P2041 JV does not see Ghlo Core as a prospect.
Ghlo Deep:

Volumetric parameters:

<table>
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<th>Min</th>
<th>ML</th>
<th>Max</th>
<th>Units</th>
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<tr>
<td>Recovery Factor Oil</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td></td>
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</table>

Volumetric range for Ghlo Deep Lead is 8-14-22 mmboe (oil plus associated gas, see summary table below).

Exploration risk elements:

- Trap: 100%
- Seal capacity: 70%
- Reservoir presence: 40%
- Reservoir deliverability: 70%
- Source presence: 100%
- Charge access: 90%

Overall chance of success: 20%. Key risk is reservoir presence.

Summary of remaining potential:

<table>
<thead>
<tr>
<th>Prospect</th>
<th>Lead</th>
<th>Discovery Name</th>
<th>Stratigraphic level</th>
<th>Reservoir Depth (m MSL)</th>
<th>Oil mmbbls</th>
<th>Associated Gas bcf</th>
<th>Geology Chance of Success</th>
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<td>Jurassic/Cret</td>
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Conclusions

The original interpretation of the Ghlo Core prospect was a T31 deepwater turbidite channel. Improvements in imaging from new seismic acquisition have shown that the Ghlo Core seismic event is T28 in age and thus not correlated with the sands observed in nearby offset wells 205/16-1 and 205/17a-1. Thin T31 sands are present in the area, but have no seismic expression in Block 205/16c. The T28 sand fairway in Schiehallion has a clearly defined eastern edge and Ghlo Core lies to the east of this.

Seismic analysis has shown that the T28 amplitude anomaly at Ghlo Core is a Class 4 AVO shale response. The anomaly itself is likely to be a condensed shale sequence on the flanks of a palaeo-high. This contrasts with known hydrocarbon-bearing channels in Schiehallion and Loyal that have Class 2, 2P or 3 AVO anomalies. The Ghlo Core amplitude anomaly no longer shows conformance with structure.
Ghlo Core is no longer considered a prospect due to reservoir presence risk. Ghlo East is no longer considered a lead, as the amplitudes associated with this are broken up and do not conform to depth structure.

A review of additional prospectivity has identified a tilted fault block lead at or about the Base Cretaceous Unconformity which straddles Blocks 205/16a and 205/16c. The reservoir here may be Early Cretaceous or Late Jurassic. This lead is considered to be too small to warrant retaining the licence.