PL378C Relinquishment Report *(DRAFT)*

Key License History

License PL378C (Fig. 1) was applied for as a carve-out of the PL378 license prior to the drilling of the 35/12-5S 'Crossbill' well. The license was granted on 09.12.2015. The license covers 139.864 km^2, fully in block 35/12. The partners were:

Wintershall Norge AS (O): 30%
Capricorn Norge AS: 20%
Repsol Norge AS: 17,5%
Explora Petroleum AS: 17,5%
Origo Exploration Norway AS: 15%

PL378 was granted on 06.01.2006. The initial phase was extended three times, on 07.01.2012, 07.01.2013 and 07.01.2014 to 06.01.2016. The PL378C carve-out application from the PL378 license in 2015 was the result of a farm-in of Origo Exploration Norway into the Crossbill exploration well, where Wintershall farmed down 15% of its original 45% equity, but excluded the Grosbeak and Skarfjell discoveries, which called for the need to split up the license. Since the 35/12-5S Crossbill well was drilled before the award of license PL378C, there were no new work obligations defined. The license was part of the PL378 license schedule; meaning one MC meeting and two EC meetings per year were held before the granted date. One final EC/MC meeting is planned in 2016 to discuss the post well studies of Crossbill and to close out PL378C.

The license area is located on the Uer Terrace, west of the Skarfjell and Grosbeak discoveries. At the time of the license award, the combined prospectivity defined by the partnership included the (Upper) Jurassic Crossbill prospect and the Jurassic Brambling prospect. Charge and migration were seen as the biggest risk for these prospects, depending on a local kitchen of the Crossbill area. The 35/12-5S Crossbill well was dry without any hydrocarbon shows. Therefore, the likelihood of Brambling receiving charge is further challenged, since the source rocks directly surrounding Brambling are not mature. The size of the updip potential of Crossbill and Brambling is further such that the prospects are not likely to be economic. It was therefore unanimously decided by the partnership to relinquish the license at the end of the initial phase on 06.01.2016.

Database

There was no new seismic acquired during the evaluation of the license. The 3D seismic used to evaluate PL378C was the merged cube: RD121WIM13. The cube is a poststack merge of the RD1201 survey in the north and the SG9603MN9201MR06 and the gaps are filled by Marflo2007 (Fig. 2). This was done to have one seismic volume covering the whole Crossbill area. The merged seismic survey is of moderate to good quality. Horizons can be tracked with reasonable confidence in Upper Jurassic reservoirs as well as intra-Brent horizons. However, lateral facies transitions in the Heather are not easy to pick up making consistent regional picking challenging. In addition, picking the exact top of the Brent Gp reservoirs is difficult due to lack of velocity contrast between Lower Heather and Top Brent. The 35/12-5S Crossbill

well was the only new well drilled in the PL378C license and only the second well in the PL378C license area outline. The other well is 35/12-1 (PL174) drilled by Saga Petroleum in 1992, which was dry with minor shows. Other key wells for the evaluation were 35/9-10S (Skarfjell, oil) and 35/9-12S (Atlas, dry). Other wells drilled in the PL378 were 35/12-2, 12-4S, 12-4A (Grosbeak, oil/gas) and 35/12-3S (Gnatcacher, dry). All these wells had the Upper Jurassic as primary or secondary target and were essential for the Crossbill and Brambling evaluation.

Review of geological framework

The poststack merged seismic has been used in geophysical and geological evaluation of the license area. This includes seismic mapping of all relevant horizons and faults, amplitude analysis and geological modelling. Geological studies have covered reservoir facies prediction, fault seal analysis and petroleum systems modelling.

The drilling of well 35/12-5S has contributed considerably to the understanding of the geological framework in PL378C. On a south-north line from 35/12-1 to 35/9-12S via Crossbill 35/12-5S it is understood how the Sognefjord Formation shales out from shoreface facies sands to offshore transition shales/silts and ultimately gaining sand content again in the Skarfjell area as intra-Heather turbidites (Figs. 3, 4). The Fensfjord Formation also shales out toward Skarfjell, gradually decreasing thickness from the 35/12-1 well towards the north, but still preserving significant thickness and reservoir quality on Crossbill and Atlas. One of the four Skarfjell wells, the 35/9-10S still has some Fensfjord in shoreface facies present. The Crossbill well also showed there is still a significant Krossfjord Formation present at the well location, with moderate to good reservoir quality. No cores were taken so no detailed sedimentological analysis can be given, but it is likely that both Fensfjord and Krossfjord are shoreface facies at the Crossbill well location.

There is no structural closure at Middle Jurassic Brent level at the Crossbill well location, but apart from the first 30 meters of interbedded Ness Fm reservoir, the Etive and Oseberg formations are present with good reservoir quality.

The understanding from regional mapping is that both Crossbill and Brambling in the PL378C have no access to charge from long range migration routes, e.g. the Sogn Graben. The catchment area for Crossbill is not larger than the outline of the maximum pre-drill upside potential (Fig. 5). Source rocks (Draupne Fm and lower Heather) are directly above and below the Upper Jurassic reservoirs. Pre-drill petroleum systems modelling using surrounding wells for offset showed that source rocks in PL378C reach maturity and start expelling hydrocarbons at present day burial depths of 2.6 to 2.8 km. Based on the GRV of the catchment area, a expelled hydrocarbon volume of 270 to 315 mmBOE was calculated. This volume would be enough to fill the Crossbill structure and eventually spilling and migrating to Brambling as well. However, TOC measurements on cuttings from the Crossbill well showed a significant lower maturity of the source rock. Despite this result, it is unlikely that nowhere within the Crossbill catchment area mature source rock is present. The dry Crossbill well can be explained by immature source rock, but it is not unthinkable that if some hydrocarbon expelled, it has bypassed the well location and migrated elsewhere. All intra-Jurassic sands had water pressures on the same (hydrostatic) water gradient. Intra-Heather seals may be inefficient or absent, which potentially makes migration more

complex than a single top reservoir map would imply. The total lack of shows in Crossbill, however, is not an encouraging sign and it increases the charge risk on Brambling greatly.
Fault seal analysis using a number of different Vclay models from offset wells concluded that the SSW-NNE trending fault east of Crossbill could support at least 90 m and up to 250 m of column below the structural spill point of the Fensfjord formation. This depends on the amount of shale between the base of the Draupne Formation and the top of the Fensfjord, but even a sandier Heather appears to have some side seal capacity. The Fensfjord was penetrated 20 m above the structural spill point of Crossbill, so should the structure have been filled to spill, the Fensfjord should have been found hydrocarbon bearing. It is not possible to rule out side or top seal failure for Crossbill, but the end conclusion remains that lack of charge is the primary failure reason.

Prospect update

Crossbill

Before drilling exploration well 35/12-5S, Crossbill was defined as an Upper Jurassic combined structural/stratigraphic trap (Figs. 6, 7). The structure was thought to have Sognefjord Fm and Fensfjord Fm reservoirs present. Shortly before spudding the planned vertical well, additional potential was identified in the upper Heather (Kimmeridgian/Oxfordian) and the decision was made to deviate the well path to include that target (Fig. 8). The well found some 10 meters of Kimmeridgian-aged interbedded sandstones just below the base of the Draupne Formation, but without hydrocarbon shows. 35/12-5S penetrated the Sognefjord Formation near the crest of Crossbill with less than 2 m net reservoir, also without shows. The prospect has a downdip structural element in the north combined with fault seal towards SE and a stratigraphic element in the east and west. The stratigraphic element consists of the truncation of the Volgian Unconformity into the Upper Jurassic with side and top seals provided by Draupne shales. The Volgian unconformity across Crossbill is an angular unconformity. This means the crest of the Sognefjord structure is not in the same place as that of the Fensfjord structure. Consequently, the well penetrated the Fensfjord (and Krossfjord) further downdip. The net sand thickness in Fensfjord is 35 m and in Krossfjord it is 32 m, with good to moderate reservoir quality (16% and 14% average porosity respectively). No hydrocarbons were found.
As explained above, it's most likely that the source rock in the local kitchen is not mature enough to expel hydrocarbons and that Crossbill has no access to long distance migration from the Sogn Graben. The P50 Sognefjord area was 1.8 km^2, the P50 Fensfjord 4.2 km^2 and the maximum area with a structural spill point in the north was 23 km^2. The mean recoverable reserves pre-drill were estimated at 4.55 $mmSM^3$ oil for the Sognefjord Formation at 27% GPOS and 4.84 $mmSM^3$ oil for the Fensfjord at 22% GPOS. The consolidated mean recoverable reserves were estimated at 7.53 $mmSM^3$ at 30% GPOS (Tab. 1). The main risks were on reservoir presence and effectiveness, followed by charge and trap effectiveness.

Brambling

The Brambling prospect is a structural 4-way closure at Base Draupne level. At Top Sognefjord there is also a stratigraphic element, namely the truncation of the Volgian unconformity (Fig. 9). Draupne shales can provide side seal along the whole western half of Brambling, the structural spill point is in the north

towards the dry 35/12-1 well. From crest to spill point at Sognefjord level gives a potential column height of some 110 m. The structure is a lot flatter on Fensfjord and Brent levels, the Volgian truncation does not cut into the Fensfjord around Brambling. With maximum column heights of less than 50 m the volume potential for Fensfjord and Brent reservoirs is very limited. The presented Brambling volumes only include the Sognefjord reservoir. The Brambling prospect is situated just 2.5 km SW of the 35/12-1 structure and the expected net sand thickness in the Sognefjord Formation is equal to that of 35/12-1 around 100 m of gross reservoir, shoreface facies. The possible presence of a waste zone between base Draupne and top Sognefjord may compromise the top seal effectiveness (Fig. 10). This waste zone might also explain the dry 35/12-1 well, apart from possible lack of access to charge. The Draupne and Heather Formation source rocks are not likely to be mature within the catchment area of Brambling, as demonstrated by various petroleum systems models and data from nearby wells like 35/12-1 and 35/12-5S. Charge would have to come from the north, bypassing the Crossbill structure. With no shows of movable hydrocarbons in Crossbill, the charge risk of Brambling has increased.
With a structural spill point at 2560 m TVDss the Brambling prospect covers an area of 5.4 km^2. The estimated mean recoverable reserves are 4.94 $mmSM^3$ of oil (Tab. 1). The main risks are on charge and top seal, both having negative indicators. The GPOS is 14%. In the current market it will be hard to make the prospect economic.

Technical evaluation

A combined production, facility and economic evaluation was completed for the Crossbill prospect. To reach a P(50) oil production level the following well count scenario was established: 4 producer wells and 3 injector wells with a tie-back to Gjøa via Skarfjell. Production profile is shown in Figure 11 . With a discovery in 2015, production could have started up in 2023. A discovery on Brambling would have similar tie-back options, but the prospect has not reached the phase for economic screening.
No discovery has been made in PL378C and the remaining prospectivity is deemed to carry too small a volume to be of economic interest. Minimum economic field size for a template development with a tie-back to Gjøa for example would have been 25 mmboe recoverable at a $ 90,- / bbl price scenario. Even at that price the mean cases are sub-commercial.

Conclusions

Having considered the remaining petroleum potential in the license (Tab. 1), which is identified solely in the Brambling prospect, the volumes in place are too small to be of economic interest and the risk too high. The decision was therefore made to relinquish the license, which was accepted by all partners.

Table 1 Resource volumes

	Crossbill pre-drill								
	oil mmbbls				assoc. gas bcf				Risk
	P90	P50	P10	Mean	P90	P50	P10	Mean	GPOS
Sognefjord	2,48	19,3	65,9	28,6	2,9	22,7	77,3	33,8	27
Fensfjord	5,18	20,1	66,4	30,4	6,0	23,8	78,0	36,0	22
Consolidation	7,53	36	99,6	47,3	8,9	42,4	117,2	55,8	30
	Brambling								
	oil mmbbls				assoc. gas bcf				Risk
	P90	P50	P10	Mean	P90	P50	P10	Mean	GPOS
Sognefjord	5,89	23,6	65	31	6,84	27,4	76	36,2	14