RELINQUISHMENT REPORT

License P1549 Block 110-05

23 November 2009
1. Introduction
Promote license P1549 comprises Block 110/05 in the East Irish Sea (Figure 1). It was awarded on 7 February 2007 as part of the 24th Round of the UKCS Licensing. The award was made to REAP UK and purchased by Sherritt International Oil and Gas Ltd (Sherritt) on 26 March 2007. The block lies to the east of the large Morecambe Bay gas field. No wells have been drilled in the block.

2. License Status
Following two years of geological and geophysical investigation of the block, Sherritt has developed a prospect in the Triassic Sherwood Group and the Permian Collyhurst Formation. The prospect lies on a horst block that straddles the boundary between Block 110/04 and 110/05. A year has been devoted to attracting a partner to participate in the drilling of the prospect. Sherritt has been unable to find a partner, and is not in the financial position to commit to drilling a well to test the prospect. The block was relinquished at the end of the 9 month extension to the first period in the promote phase (09 November 2009).

3. Status of Work Program
The following work program has been completed since the award of the license:
- Licensing of 7000 line–km of 2D seismic and 700 km$^2$ of 3D (Lennox and Morecambe North and South) from Geospec.
- Licensing the central part of the East Irish Sea aeromagnetic survey from Geospec.
- Reprocessing of 1786 line-km of 2D data to Prestack Time Migration stage.
- Reprocessing of 774 line-km of 2D seismic data to Prestack Depth Migration stage.
- Interpretation of the seismic data over the block tied to wells 110/04-1, 110/10-1, 110/09-1, 110/09a-2, and 113/29-2.
- Comparison of prospect to the Lennox and Ormonde fields, and the Marram and Whitbeck prospects.
- Remapping the Formby Point Fault across the block and into Morecambe Bay.
- Core and outcrop study of the Triassic and Permian sandstones, and the Dinantian carbonates.

4. Exploration History
In the East Irish Sea, hydrocarbon exploration has been focused on the Triassic Sherwood Group sandstones (see Figure 2 for the stratigraphy). There are 19 fields in the basin producing mostly gas (Figure 3). To date over 10.7 Tcf of gas and 330 mmbbl of oil have been produced. The Permian Collyhurst Formation has been the target of several exploration wells and it has tested hydrocarbons, but the only production has been from an onshore well in the Elswick field (Figure
3). The Carboniferous carbonates and sandstones have been considered as reservoir rocks and shows indicate some potential in the East Irish Sea.

The dominant source rock in the basin is the Namurian Hollywell shale. There may be some contribution from the Westphalian Kidston Group coals.

The seal is produced by a thick section of Triassic evaporites and shales in the Mercia Group. The Mercia Group is absent over several structural highs in the centre of the basin so a major risk in the basin is the presence of a thick enough section of Mercia Group to provide a competent seal. The presence of the giant Morecambe field indicates that less than 400 m of Mercia is sufficient to form a seal, provided several key evaporate units have been preserved. The seal for the Permian Collyhurst reservoir is an upper Permian evaporite/marl sequence known as the Manchester Marls.

Structural inversion of the basin during tectonic episodes in the Jurassic, Late Cretaceous, and Tertiary has complicated the history of hydrocarbon generation, and may have resulted in the loss of an early Jurassic oil charge.

5. Regional Geological Setting
The East Irish Sea basin is one of several sub-basins that form in a line extending from south of London, across Cheshire, and extending out into the Irish Sea. The sub-basins are separated by basement highs. The basins formed as a result of extension during the early Permian, that produced a set of NNW trending normal faults, overprinting the EW oriented structures of the Carboniferous Hercynian and Variscan orogenies. The Permian sandstones, marls, and evaporites were deposited into shallow marine, fluvial, and terrestrial environments. The Triassic era was dominated by a major drainage system extending from central Europe northwest towards the North Atlantic. The lower Triassic sediments are a mixture of aeolian and fluvial sands. The upper Triassic Mercia Group mudstones and evaporates were deposited during a shallow marine incursion and the development of a restricted marine environment.

A major uplift in the late Jurassic re-activated the normal faults and resulted in the erosion of the Jurassic section and the breaching of the early hydrocarbon traps. The Cretaceous section is also missing in the basin so little is known about the Cretaceous history. The Alpine orogeny in southern Europe resulted in the development of a foreland basin and the burial of the East Irish Sea basin into the main gas generating phase. Uplift and erosion has removed most of the Tertiary section. Glaciation during the Quaternary has deposited a thick section of till over the basin. Quaternary channels have cut down to the Triassic reservoirs in parts of the basin.

6. Exploration Potential of Triassic Sherwood Group
The main reservoir in the East Irish Sea basin is the Triassic Ormskirk Formation at the top of the Sherwood Group (Figure 2). The sandstone is a medium grained
sub-angular to sub-rounded quartz arenite with 10-20 \% porosity. Hydrocarbon traps are formed structurally where the Ormskirk Formation is present on an up-thrown horst block and is sealed above by the Mercia Group mudstones, and laterally by faults or the same Mercia Group. Traps are also formed in anticlines produced during compressive re-activation of the normal faults.

Figure 4 shows a structure contour map of the top of the Sherwood Group. The Ormskirk Formation is present over the entire block. The Formby Point Fault subcrops under the Quaternary cover, just offshore of Blackpool Beach. The reprocessed seismic lines show the listric nature of the Formby Point Fault. There is evidence for several small antithetic faults in the hanging wall. These faults may form small structural closures at the Ormskirk level, but the lateral extent of these structures is not well mapped with the seismic. The Formby Point Fault divides into several branches as it crosses the entrance to Morecambe Bay.

The reprocessed seismic data clearly show the presence of a deep sub-basin in the centre of Block 110/05. The top of the Carboniferous is seen as a strong reflector at a depth of 2500 m. The seismic line in Figure 5 shows the angular unconformity at the top of the Carboniferous. The Permian Manchester Marl and Lower Triassic are fairly transparent in the seismic section. The base of the Sherwood Group (St Bees Sandstone) is a strong reflector. The Mercia Group is mapped by the presence of strong reflectors associated with mudstones and halites.

The imaging of the narrow horst block at the western edge of Block 110/05 is complicated by the location of the seismic grids and the orientation of the lines relative to the structures (Figure 6). The application of prestack depth processing to the lines has improved the imaging of the west dipping fault on the western edge of the horst, but the internal strata, and the eastern edge of the horst are still poorly imaged.

Based on the improved seismic imaging, a section of Sherwood Group Sandstone capped by up to 500 m of Mercia Group has been mapped over the horst. Figure 7 shows the interpretation of the structural closure (minimum = 480 hectares, maximum = 1270 hectares). Using this range of areas, the prospect is likely to yield a reservoir somewhere between the size of Lennox (497 Bcf) and South Ormonde (40 Bcf).

The main risk in the prospect is the poor imaging of the northern end of the horst, which leaves some uncertainty as to the amount of structural closure. The sealing capacity of the large faults is usually good provided they have juxtaposed a mudstone or halite against the reservoir unit. However, the small faults that have been mapped across the horst block may have variable seal quality.
The dominant hydrocarbon in the region is dry gas. Based on the results from adjacent wells the risk of encountering high nitrogen saturation in the gas is significant. The origin of the nitrogen is not known.

7. Exploration Potential of Permian Collyhurst
A lower Permian sandstone (Collyhurst Formation) has been observed in wells Elswick 1 and Thistleton 1, onshore to the east of the block. In both wells the sandstone is low porosity and very well cemented (Figure 8). The reservoir quality is lower than the Triassic Sherwood Group. The Collyhurst Formation has been targeted by several exploration wells in the East Irish Sea basin as it can form a trap on the top of an up-thrown Carboniferous horst block. The Collyhurst Formation may be present on the horst block mapped on the boundary between Block 110/04 and 110/05. However, the main risk is the presence of porosity.

8. Exploration Potential of Carboniferous
The Carboniferous sandstones (Westphalian and Namurian) and limestones (Dinantian) are potential reservoirs provided there is an increase in porosity. The proximity to the source rocks is an advantage, and the presence of a major unconformity at the base of the Permian is attractive. Figure 5 shows the presence of a major angular unconformity at the top of the Carboniferous, and the strong reflectors associated with the Westphalian coals. More detailed work is required to identify possible mechanisms for enhancing porosity in the Carboniferous sandstones and carbonates, before any leads can be mapped. The risk that sandstones, above the base Permian unconformity, can form a thief zone needs to be studied in more detail.

9. Other Geological Risks
Tertiary igneous rocks are present across the East Irish Sea basin. The magnetic map over Block 110/05 shows that a splay of the Fleetwood dyke crosses the northern part of Block 110/05 (Figure 9).

A major Quaternary channel containing sands, gravels, and clays cuts across the block from the northeast to the southwest. It underlies part of the Lune Deep channel (seen on the bathymetry map in Figure 1) and complicates the seismic processing. There is a risk of the Mercia Halite seals being breached by ice and fluvial scouring during the last glaciation.

In general, the shallow water depths (5 – 15 m) over the block is a logistical problem for a jack-up drilling rig, so an extensive geotechnical investigation would be needed prior to choosing a drilling location.

10. Conclusions
Block 110/05 lies mostly on the hanging wall of the Formby Point Fault. The Sherwood Group is present over most of the block and is uplifted into a potential hydrocarbon trap on a narrow horst on the western edge of the block. The
Permian Collyhurst Formation is found in the same structure, but the porosity of the unit is likely to be low.

The prospect mapped is large, but lies partly in Block 110/05 and partly in Block 110/04. The northern closure to the structure is poorly resolved by the 2D seismic grid. Despite detailed velocity analysis and time-depth conversion there is a risk that the structure remains open at the northern end of the horst block. Given the geological risks, and the low level of interest from potential partners, Sherritt decided to relinquish the block at the end of the 2 year promote phase.

11. Clearances
Sherritt International Corporation confirms that DECC is free and clear to publish this relinquishment report.

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Figure 1  Location map
Figure 2  Stratigraphic column
Figure 3  Oil and gas fields
Figure 4  Time structure on top of the Sherwood Group
Figure 5  EW seismic section across the prospect
Figure 6  NS seismic section across the prospect
Figure 7  Sherwood Group prospect in Blocks 110/04 and 110/05
Figure 8  Core photos from Elswick 1 : Collyhurst Formation.
Figure 9  Faults and igneous dykes in the vicinity of Morecambe Bay.
Figure 1: Location of Block 110/05 and the bathymetry of the East Irish Sea
Figure 2: Stratigraphic column for the East Irish Sea basin
Figure 3: Map of oil (green) and gas (red) fields in the East Irish Sea basin.
Figure 4: Depth structure on top of the Sherwood Group from well data and 2D Seismic. The Formby Point Fault lies on the eastern edge of the block. A major fault forms a narrow horst that lies on the boundary between Block 110/04 and 110/05.
Figure 5: PSDM reprocessed seismic line across the prospect (EW line from Figure 4). Prospect lies on the footwall of the west dipping Main Fault.
Figure 6: PSDM reprocessed seismic line across the prospect (NS line from Figure 4). The west dipping main fault is sub-parallel to the section and cuts through the section reducing the data quality at the northern end of the prospect.
Figure 7: Sherwood Group Prospect on border between Block 110/04 and 110/05. The main risk is the potential lack significant closure at the northern of the structure.

Max Area = 1270 ha
Base = 825 m SS

Min Area = 480 ha
Base = 725 m SS

Crest = 650 m SS

Sealing Fault

Poor seismic in complex fault zone.

Antithetic Faults: non-sealing?
Figure 8: Core Photos from Elswick 1: Collyhurst Formation: 3427 – 3547 ft measured depth. Very-fine-grained well-rounded quartz arenite with quartz and calcite cement. Porosity = 2 – 12 %, Permeability = 0.01 – 8 mD (DTI well file).
Figure 9: Faults and igneous dykes in the vicinity of Morecambe Bay.