Introduction to the North Falkland Basin revisited: exploration and appraisal of the Sea Lion Field

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The eight papers in this issue of Petroleum Geoscience form a thematic set that describes the recent advances in understanding of the structural development, stratigraphic evolution and sedimentary history of the North Falkland Basin, and the combined impact that they have had on its petroleum geology with a focus on the Sea Lion Field. The set of papers evolved from integrated geoscience carried out by Rockhopper Exploration plc and their contractors following the discovery of the Sea Lion Field and its subsequent appraisal.

The geology of the Falkland Islands and surrounding basins has been of interest to geoscientists for a considerable time for both academic and commercial reasons. Fieldwork carried out in the early 1920s (Baker 1924) was subsequently updated by a photo-geological survey supported by the British Antarctic Survey (Greenway 1972). However, it was not until 1996 that the British Geological Survey resurveyed the islands and produced the first modern geological map (Aldiss & Edwards 1999). Despite the complex and interesting onshore geology and fascinating geomorphological features, the islands themselves have no documented onshore hydrocarbon potential.

In 1977–78, several thousand kilometres of speculative seismic data were acquired in the shallow waters surrounding the Falkland Islands. These data allowed the identification of several sedimentary basins; a passive margin to the east (the Falkland Plateau or East Falkland Basin), a thrust belt to foreland basin setting to the south (the South Falkland Basin), the Malvinas Basin to the west and, to the north of the islands, an extensive rift basin known as the North Falkland Basin. Several Deep Sea Drilling Project (DSDP) boreholes drilled on the Maurice Ewing Bank proved the presence of a Late Jurassic–Early Cretaceous source rock (Barker et al. 1976), and exploration of the Malvinas Basin by Esso in 1982 resulted in two non-commercial discoveries. Despite these encouraging results, it was not until 1998 that the North Falkland Basin gained the attention of the explorers. The first round of licensing stimulated much interest, and led to the acquisition of significant two-dimensional (2D) seismic data, one 3D volume and the drilling of six exploration wells in the basin. Despite the exploration campaign proving that an active petroleum system existed in the North Falklands Basin, the occurrence of oil and gas shows in five of the exploration wells proved an insufficient incentive to maintain momentum, and the majors embarked on a phase of divestment through farm-out and relinquishment.

Revisiting acreage already relinquished by the majors is often an investment challenge. However, encouraged by work of the British Geological Survey (BGS) (as advisors to the Falkland Island Government), who identified the potential for a new structural–stratigraphic play on the eastern margin of the basin (Richards & Hillier 2000), Rockhopper acquired licences including a farm-in to license PL004 operated by Desire, an independent which was the only company to stay engaged in exploration in the North Falklands Basin following the exit of the majors at the end of the first drilling campaign. Rockhopper’s geotechnical work resulted in the identification of a number of east flank stratigraphic prospects that led to a second phase of exploration drilling in the basin and the discovery of the Sea Lion Field in 2010.

Rockhopper opted to collect a comprehensive dataset in each of the exploration and appraisal wells they drilled. This has provided a rich source of material that has demonstrably advanced the understanding of the petroleum geology of the North Falkland Basin and brought the first field development in the islands’ nascent oil industry one step closer to fruition. This thematic set both explores and advances the understanding of the key elements of the North Falkland Basin petroleum system at a variety of scales, with a focus on the description and characterization of the Sea Lion Field.

Lohr & Underhill integrate a comprehensive set of data to build a tectonostratigraphic framework that describes the evolution of the North Falkland Basin and shows the importance of rift transection in southern areas of the basin. Their work provides the all-important framework and context for the elements of the petroleum system, a predictive model to aid further exploration and, importantly, constrains some of the interpretation ambiguities at the field scale.

MacAulay documents the petroleum exploration of the North Falkland Basin and the two phases of exploration drilling. Given the size of the basin (c. 200 km long by 50 km wide), it is a little surprising that, following the first phase of drilling, the early explorers relinquished their interests after only six wells, and having proved a working hydrocarbon system. But, in 1998, a graphically remote area with no infrastructure and falling oil prices was, no doubt, a difficult set of conditions from which to generate shareholder enthusiasm, even for the most aggressive explorers. However, change is a window of opportunity, and the exit of the large and mid-sized explorers created space that, in time, was filled by a new generation of small independent companies, of which Rockhopper was one.

The linkage between reservoir fluids, source rock distribution and burial history are commonly overlooked in more mature petroleum provinces. However, in frontier areas, understanding the geochemistry of the discovered hydrocarbons and source rock is essential for future exploration and development planning. In what is the first publication on the petroleum geochemistry of the North Falkland Basin, Farrimond et al. consider the characteristics of the oils, the correlation between fluids and source rocks, and the hydrocarbon charging history of the Sea Lion Field.

Bunt exploits the excellent 3D seismic dataset that covers the Sea Lion Field and describes the detailed seismic interpretation of the reservoir fan bodies. The use of attributes not only adds confidence to the mapping of the fans but also helps in the understanding of their geomorphology, which has applications for field-development planning and defining future exploration targets.

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Whilst robust interpretation of the seismic reflectivity data underpins the description of the gross reservoir framework, one of the desired outputs of the geophysical process is seismically derived quantitative reservoir interpretation. Francis et al. describe the use of extended elastic impedance (EEI) as a seismic analysis tool and the coloured inversion of the EEI volume, which has been used as a sand predictor. The challenges of working with reservoirs at, or close to, tuning thickness are discussed.

Holmes et al. describe the process of setting up the chronostratigraphic framework through the use of biostratigraphy and the challenges associated with the lack of regionally occurring age-diagnostic taxa in fluvial–lacustrine deposits. The use of chemical stratigraphic analysis is investigated as a technique to improve stratigraphic resolution in the reservoir sands.

From the extensive core inventory acquired during the 2010–11 drilling campaign, the detailed sedimentology of the reservoirs is described by Williams, who presents a reconstruction of reservoir architecture and palaeogeography of the basin in early Cretaceous times.

Finally, Griffiths explains the integration of static and dynamic data to characterize the reservoir as input to robust geocellular and dynamic models for the purposes of volumetric calculation, flow simulation and reserves estimation.

Collectively, these papers advance the understanding of the petroleum geology of the North Falkland Basin at both the regional and field scale. Together they provide a powerful example of the value of acquiring a comprehensive dataset during the exploration and appraisal stages of drilling, and the benefits of applied integrated geoscientific study.

The success in the North Falkland Basin shows the benefit of adopting an integrated approach to petroleum exploration. Not only has it resulted in a commercially viable oil discovery at the Sea Lion Field, the datasets acquired have helped to significantly improve the understanding of the basin as a whole and has highlighted further exploration opportunities. Whilst this is a welcome conclusion to the second phase of exploration in the North Falkland Basin, it is recognized that this is only the beginning of the journey. Future field development and exploration results will test and validate much of the work documented in this thematic set; along with the anticipated success, there will, no doubt, be new surprises. We look forward to reporting on both in the future.

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References


