

Drilling results from the North Falkland Basin

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The Falkland Islands' offshore exploration area extends to over 400,000 km², and contains several Mesozoic sedimentary basins. Following a competitive licensing round in 1996, 14 oil companies took seven concessions in the North Falkland Basin, an undrilled half graben directly north of the islands [Fig. 1].

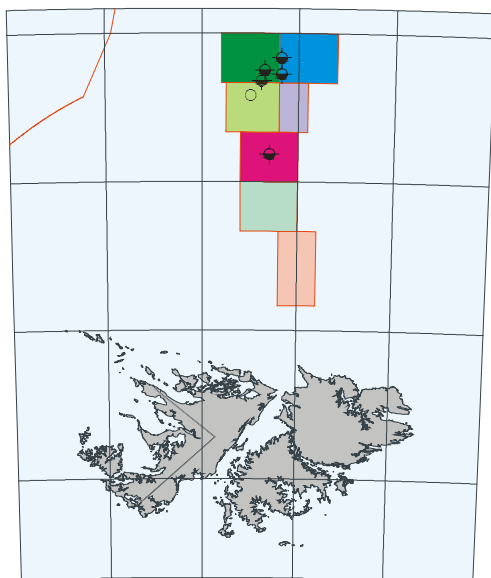


Fig. 1. Permits in the North Falkland Basin, with locations of the six wells drilled back to back in 1998.

Led by operators Shell, Amerada, Lasmo and IPC/Lundin Oil, the various consortia quickly acquired extensive seismic databases to supplement the existing speculative data that had been acquired in the region several years earlier by Spectrum Energy. These new data included a large 3D survey, shot by Shell, and thought to be the southernmost exploration 3D survey shot anywhere in the world. Fast-track drilling followed, with the first well spudding in April 1998, just 18 months after the award of licences. Given the remoteness of the region, and the absence of proprietary data at

the beginning, this was a remarkably quick start to the exploration campaign.

Sharing agreement

Not only was it a quick start to exploration, it was also innovative. The four groups that had committed to early drilling combined to form a unique sharing operation, called FOSA - the Falklands Offshore Sharing Agreement - which undertook all of the logistics and support work to facilitate a multi-well drilling campaign. The FOSA operation had many benefits, both for the oil companies concerned and the Falkland Islands Government, and it is therefore worth outlining its main components.

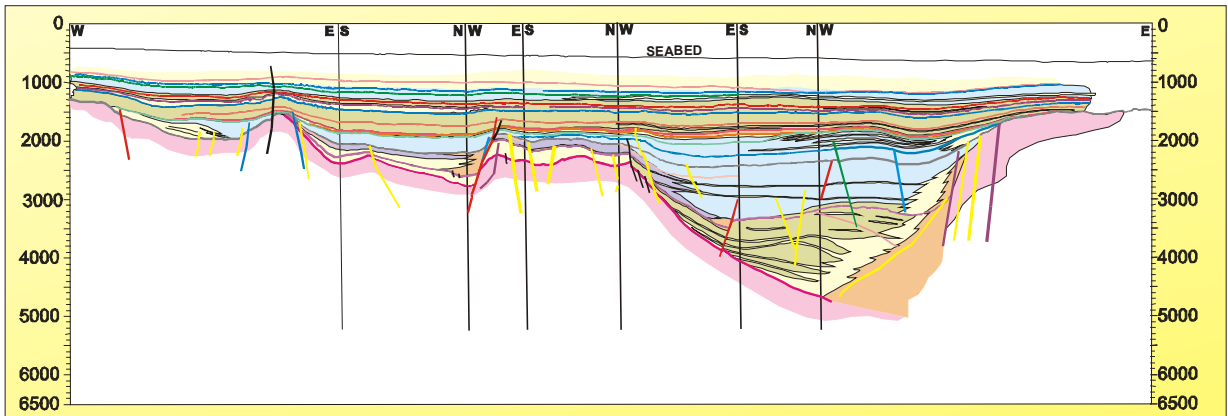
FOSA was established as an umbrella organisation led by a steering committee composed of each operating company. Each company also took direct responsibility (answering to the steering committee) for one or more aspects of the FOSA agreement. In all, there were seven areas covered by the agreement: drilling services (managed by Amerada Hess); the operations base and supplies (managed by Lasmo); health and safety issues, aviation and site survey work (all managed by Shell); environmental work (managed by Lasmo); and finance/tax (managed by Amerada and Lasmo).

FOSA determined that the greatest economic advantage lay in sharing a single rig, supply base, aviation link, site survey facility and operations/logging staff, and therefore contracted all the required services for a minimum six well drilling campaign on this basis. The main advantages that this agreement afforded the companies was a calculated saving of over £24m each, and larger pool of expertise than could be provided in-house, greater flexibility than if they were each mounting a single or two well drilling operation, a reduced manpower requirement, and a unified voice on many issues. It also gave the companies enhanced bargaining power when dealing with suppliers.

However, the FOSA advantages were not restricted to the operators, with the Falkland Islands Government also benefiting from the agreement in many ways. The Falklands is a very small community (just over 2,000 people), and there were pre-drilling concerns that a multi-rig scenario, with separate supply bases, might impact adversely on local employment. The single FOSA supply base had a minimal operational/manpower impact on the community. However, the biggest advantage to the community was probably in

terms of the amount of environmental protection and associated monitoring that was

Fig. 2. West to East cross section of the North Falkland Basin highlighting (in blue)



the stratigraphic distribution and thickness of the main oil-prone source rock.

conducted by FOSA. The combined effort was to some extent extended by peer pressure (despite the costs), and inevitably led to a significantly enhanced environmental model than if the companies had managed individual environmental projects. This was an important aspect for the Government, which had legislated fully to ensure the highest standards of environmental protection and awareness in this unspoilt haven, where the coasts teem with sea-life and sea-birds.

The FOSA agreement did, however, have one major draw-back. Because the operators were sharing a single rig, with the clock continuously ticking and a daily rental rate near the peak of the market, there was no time available for analysis of well results before the next well had to be spudded. This problem was compounded by the fact that the drill sites had been chosen at least six months in advance, in order for the necessary site survey works to be undertaken using a single survey vessel drafted in from the UK. Although most of the operators surveyed several possible sites, each was chosen on the basis of pre-drilling knowledge, and there was no chance to pick completely new locations, with new play concepts, based on the results of the wells as they were drilled. Consequently, only a small number of play types were actually tested, and extensive post-drilling analysis (conducted slowly and with the benefit of hindsight) has identified several other play concepts that might have been better options for drilling.

Oil recovered

Despite the minor draw-backs of the sharing agreement, the drilling campaign was a great success, with five of the six wells drilled

having oil shows, mostly in post-rift sandstones located immediately above the main source rock interval. Live oil was recovered at surface from one of the Shell wells: the oil has an API gravity of 27.1°, and was expelled from a mature source rock. Significant levels of gas were also recorded in some wells. Although none of the wells encountered commercially viable accumulations, sufficient was learnt about the basin and its petroleum systems to anticipate success in future operations.

In simple terms, the basin contains thick, syn- and post-rift lacustrine claystones [Fig. 2] with oil source potential. These source rocks are of world-class quality.

The generation of oil from these claystones starts at around 2,700m below sea level, and peak generation will occur in source rocks buried to greater than 3,000m below sea level. The main oil-prone source rocks have not yet been penetrated in a setting deeper than the 3,000m peak oil generation threshold, although they are more deeply buried in the central, undrilled parts of the basin [Fig. 3].

Up to 60 billion barrels

Up to 60 billion barrels of oil may have been generated in the basin. This figure is based on the source rock pyrolysis data obtained from the wells, and assumes a 400m thick mature interval at the base of the source succession, extending over an area of 40km by 40km. However, even when the calculations are based on much more conservative figures for the thickness and extent of the mature source and the richness and generative potential of the kerogens, significant amounts

of expulsion are also calculated. For example, a 200m thick mature zone, over an area of 35km by 12km, may have expelled over 11.5 billion barrels of oil, even at oil yields of 8 kg HC/tonne, which are towards the low end of those observed by rock-eval pyrolysis for this basin.

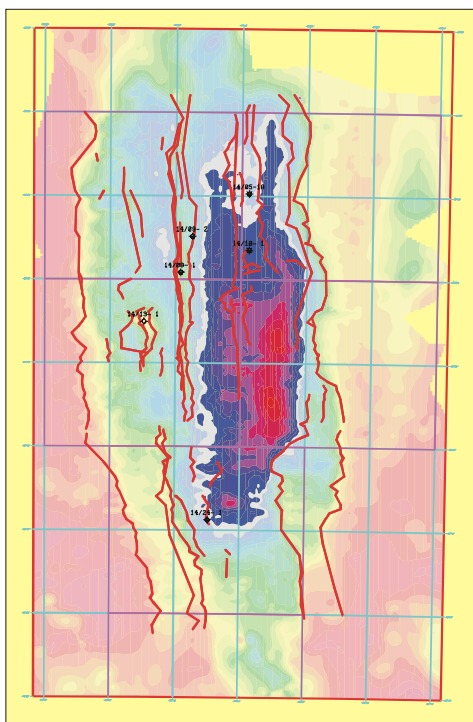


Fig. 3. The area of mature source rock in the eastern part of the North Falkland Basin. Only one well penetrated the mature part of the source rock, and even that one stopped just near the top of the mature interval.

The greyish brown lacustrine source rocks are similar to the Upper Permian lacustrine source rocks of the southern Junggar Basin of NW China, which are the richest and thickest petroleum source rocks in the world. Calculations of Source Potential Index (obtained by multiplying the organic content of the rock by its thickness and potential hydrocarbon yield) suggest that the North Falkland Basin source rocks are second only to the Junggar Basin in terms of their oil potential.

All six exploration wells encountered reservoir rocks. These reservoirs range in age from Upper Jurassic to Upper Cretaceous. Some significant sandstone intervals have been recorded. For example, Shell well 14/5-1A encountered a total of 390 m of net reservoir with an average porosity of 13%, whilst Shell

well 14/10-1 had a total of 84 m of net sandstones, with porosities averaging 27.5%.

Migration pathways are key

An understanding of migration pathways and seals may provide the key to predicting the presence of hydrocarbon accumulations in the basin. The most effective and viable top seal within the basin is probably provided by the main source rock interval itself. The uppermost 600 metres or so of the source rock is above the oil generation window in the central parts of the basin. The entire source interval is normally pressured, although it has an anomalously low velocity due to its high organic content. Since the claystones are not overpressured, there are only ineffective vertical migration pathways through it, and hydrocarbons will therefore more likely have migrated laterally down-section, along the higher permeability, more horizontal migration channels provided by sandstones within or just below the claystones. However, vertical migration into the post-rift sandstones lying above the source/seal (that were the principal targets of the drilling campaign) might be possible where traps lie close to penetrative faults which provide a migration pathway down into the main kitchen area.

Untested plays

Lateral and down-section migration would tend to favour the accumulation of oil either near the basin margin, or in tilted fault blocks and stratigraphic traps beneath the claystone blanket (as in the Brent Province of the North Sea). Such targets have not yet been adequately tested, and include: Jurassic to earliest Cretaceous fan sandstones, deposited during the syn-rift phase, along the margins of the basin in situations analogous to the Brae complex in the South Viking Graben; early Cretaceous sandstone-dominated deltaic bodies that prograded into the basin from the marginal areas during the early post-rift phase, and that may be sand-rich and closer to migration pathways, particularly those associated with the basin margin faults; shoreline and/or transgressive sandstones of Aptian to Albian age that may have been deposited along the margins of the basin during the initial overstepping of the flanks in the post-rift phase; numerous closed highs in several discrete, deep sub-basins in the southern parts of the North Falkland Basin, where the stratigraphy may be different to that encountered in the six wells; and fan sands

with associated channels developed within the lacustrine source rock succession itself.

In summary, one of the richest source rock intervals anywhere in the world has been encountered in the North Falkland Basin, capable of generating up to 70 kg HC/tonne of rock, and it may have expelled up to 60 billion barrels of oil. Some thick (approximately 100 metre) sandstones have been encountered above the main source rock interval, with porosities ranging up to about 30%, but these are not on the optimum migration pathways. Very few thick sandstones with good reservoir properties have yet been encountered in the syn-rift succession beneath the main source rock interval, but few of the wells have penetrated this section. The absence of overpressures within the source rock suggests that any expelled oils may have migrated laterally, and they may therefore be trapped preferentially in syn-rift reservoirs developed beneath and lateral to the main source rock interval.

Opportunities

Exploration opportunities in the basin are available either through farm-ins to existing licences (with the advantage of significant data access in most cases), or through the new open-door licensing policy to be pursued by the Falkland Islands Government. Details of opportunities can be obtained from the author: p.richards@bgs.ac.uk

More details

More details of the geology of the basin can be found in two papers published by Phil Richards and Ben Hillier (Shell) in the *Journal of Petroleum Geology*: 2000, v 23(3). This paper is published by permission of the Falkland Islands Government and the Director, British Geological Survey (NERC).