Introduction

Modern AVO-compliant seismic data was acquired in 2013 to chase the Dinantian subcrop-to-Base-Permian Play Fairway on the northern flank of the Southern North Sea’s Sole Pit Basin. Located north-east of the Breagh Field, these data have imaged the intra-Carboniferous remarkably well, allowing the potential of this sequence to be mapped and evaluated with confidence for the first time. The long record length, together with the innovative processing methodology targeted at improving the subsalt section, resulted in a dataset that images base Permian structures (similar to Breagh Field) in open acreage, and also long suspected, yet previously unimaged intra-Carboniferous fault block and independent structural closures. Subsalt pre-stack seismic inversion, encouraged by the remarkably good seismic quality at intra-Carboniferous level, greatly supports and de-risks the intra-Carboniferous Dinantian prospect delineation.

Dinantian Play Fairway

The UKCS Southern North Sea has two major NW-SE trending play types defined by the distribution of Permian Rotliegend and Carboniferous Westphalian/Namurian gas fields. Due to the geometry of the Base Permian unconformity, the Carboniferous is increasingly eroded on the northern flank of the Sole Pit Basin, where the section encountered is the sandstone rich Dinantian (Early Carboniferous) Yoredale Formation (YF), Scremerston Formation (SF) and the Fell Sandstone Formation (FSF) (Figure 1).

The first well into the Breagh field (42/13-2), drilled by Mobil in 1997, encountered the SF which contains reservoir quality channel sandstones with interbedded shales and thin coals subcropping to Base Permian. In 2007 Sterling Resources tested the formation at commercial flow rates (17 mmscf/d) and the field was brought on production in Q3 2013. The Breagh 2P Reserves are reported at 604 BCF and P50 contingent resources for the adjacent Crosgan Field are 101 BCF respectively, establishing the potential of this play fairway for significant discoveries.

Seismic Data Characteristics

During the second half of 2013, Spectrum acquired and processed 4,017 km of new 2D Multi-Client data over open acreage to facilitate exploration of the SF and FSF play fairways, north-east of the Breagh-Crosgan fields (Figure 2, overleaf).

The data was collected with an 8 km cable, nominal 160 fold with 10 second record length. Close collaboration between interpreters and processors from an early stage identified the Top Chalk as a generator of strong multiples which masked the deep section. Successive iterations of de-multiple techniques, including dual domain Tau-P Decon, delayed start SRME at Top Chalk level (Figure 3, overleaf) and high resolution radon had the greatest positive impact at Permian and intra-Carboniferous levels and allowed the processors to pick a very accurate velocity field ahead of application of an aggressively targeted pre-PSTM radon. All data dependent scaling applications were avoided in the processing sequence. The successful amplitude preserving processing schedule, aimed at de-noising the data and enhancing the subsalt image, enabled proving the use of pre-stack inversion over a small test area as an additional tool to delineate some new prospects.

Figure 1 South-North transect illustrating base Permian unconformity erosional geometry and simplified Carboniferous stratigraph
Pre-stack Inversion Methodology and Results

Pre-requisite to meaningful inversion results is good quality data – both well and seismic. The area for the inversion trial was covered by two wells, 43/02-1 & 43/06-1 (Figure 4, overleaf). Careful attention was given to the initial clean-up and verification of these wells, involving anomalous sample edit, missing log data transforms and well to seismic tie/correlation using time-depth charts exported from the interpretation project. Nine regional horizons, augmented by locally picked horizons to delineate faults within the Inversion software, along with both wells, were used in the model building stage. The pre-stack inversions for the individual lines were run using consistent scalars, which allowed meaningful comparisons across the results. Lambda Rho and Mu Rho volumes were also generated from the P and S wave Impedance volumes. Cross-plotting of the various data volumes gave consistent results for the predicted distribution of gas bearing sands.

Intra-Carboniferous Dinantian Play Potential Endorsement

Multiple independent structural closures, fault-closed structures and erosional updip terminations against Zechstein salt were all identified at SF level. Very large one-way fault and three–way dip closed structures as well as independent structural traps were mapped at FSF level. Various crossplots derived from the pre-stack inversion results, with data points corresponding to potential gas-bearing sandstones, were successfully integrated with leads identified from seismic interpretation and depth conversion (Figure 5, overleaf). This illustrates not only the potential for the FSF to represent a significant bulk rock volume of gas bearing high quality sandstone in stratigraphic and fault bounded traps, but also the potential for pre-stack inversion to play a key role in the search for, and de-risking of such plays.

This has only been made possible because of the high quality of the seismic dataset, due to careful processing and integrated efforts of the data processing and seismic interpretation teams.
Conclusion

Modern, dense, high quality 2D seismic data interpretation, integrated with pre-stack inversion results, has resulted in a detailed understanding of the Dinantian play fairway and a comprehensive prospectivity analysis for new intra-Carboniferous play types. Successful recognition of significant, high value prospectivity has been validated by detailed prestack inversion analysis, which appears to be an essential part of the exploration workflow in the Lower Carboniferous play of the northern margin of the Southern North Sea’s Sole Pit basin.

Figure 4 (right) Location of the two wells and seismic lines used for prestack inversion

Figure 5 (below) Pre-Stack Inversion Results

About Spectrum

Spectrum provides innovative Multi-Client seismic surveys and high-quality seismic imaging services to the global oil and gas industry from offices in the UK, Norway, USA, Egypt, Australia, Indonesia and Singapore. Spectrum designs, acquires and processes seismic data to deliver high quality solutions through its dedicated and experienced workforce.

Spectrum holds one of the world’s largest libraries of Multi-Client 2D marine seismic data. The company’s strategy focuses on both the major, established hydrocarbon-producing regions of the world as well as key frontier areas identified by our experienced team of geoscientists. The Spectrum library of Multi-Client data contains projects from many of the foremost oil producing regions of the world. These include new acquisition, reprocessing and interpretation reports.

References


BGS, 1993, Lithostratigraphic nomenclature of the UK North Sea: Carboniferous and Devonian of the Southern North Sea


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