TECH LINK

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North Sea Lower Cretaceous: A new look at an underexplored play

Introduction

Managing risk, especially financial risk, will always be a primary concern in the business of oil exploration. Exploration wells, especially in frontier areas or plays, can be particularly expensive, and even if successful may not see a viable return for several years. Access to good quality multi-capability data which gives an optimum understanding of the regional geological framework is one key way to reduce exposure to initial risks, and obtaining such data in advance of future exploration needs must always be the best way forward.

To address this question of risk PGS has created numerous regional merged 3D datasets with regional framework interpretations and associated products. These MegaSurvey studies have proven increasingly valuable to explorationists, and provide a standardised regional overview allowing basin scale evaluations, but with the resolution capable of defining prospects or field extension opportunities.

To build on the potential of the MegaSurvey data, a range of different approaches is available to take the interpretation to the next level of detail. The North Sea Lower Cretaceous study represents the first of these added value studies, undertaken with Colin Oakman Associates, well known experts in the Lower Cretaceous with over 20 years experience (**Figure 1**).

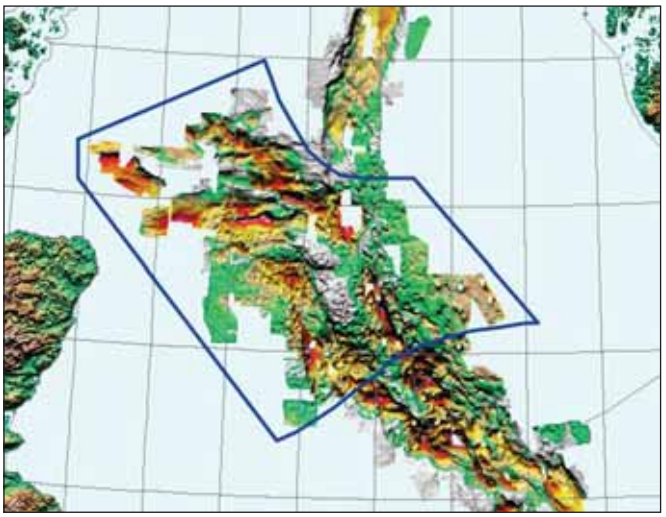

Figure 1: Location map showing CNS MegaSurvey outline and study area for the Lower Cretaceous project.

Summary

This study has used the laterally-extensive PGS CNS (Central North Sea) MegaSurvey 3D seismic volume and all relevant released exploration and appraisal wells (over 1,200 wells) to create a systematic seismo-stratigraphic model for the Lower Cretaceous over some 34,000 km^2 of the Central North Sea; spanning the Moray Firth, Witch Ground Graben, South Halibut Platform, East and West Central Grabens. As part of this study, all project wells have been re-examined to create an entirely new standardized tops, sands and shows database. At the same time significant geological intervals comprising the Cenomanian, Albian, Aptian and Barremian intervals have been correlated with the seismic data, and new structural surfaces produced so that a consistent set of depositional models can now be displayed for the Lower Cretaceous. These data have been integrated using GIS processes to create a powerful new tool for analysing fairways and helping determine hydrocarbon prospectivity of this overlooked play.

Methodology

The existing MegaSurvey data, wells and interpretation gives the Lower Cretaceous Study the same head-start as our MegaSurvey clients. The first step in producing a more focussed interpretation is to enhance the well database from exploration standard containing very basic information, to near development standard by obtaining and loading extensively QC'd and updated time-depth data and all available deviation surveys to ensure wellbore intersections with seismic surfaces are as accurate as possible. Having "set the scene" in this way by using some 1,200+ wells, all available log and

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Methodology

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biostratigraphic data was obtained and thoroughly reinterpreted by Colin Oakman Associates (COA). This reappraisal of data was guided by our extensive regional 3D seismic to create a uniquely consistent set of well tops designed from the outset to support a highly detailed seismic interpretation programme looking at the Lower Cretaceous interval. Indeed up to 50 tops were identified both regionally and more locally. It is the first time such an extensive and disparate dataset has been brought together and a reappraisal of available well data, allied to seismic, has been attempted (**Figure 2**).

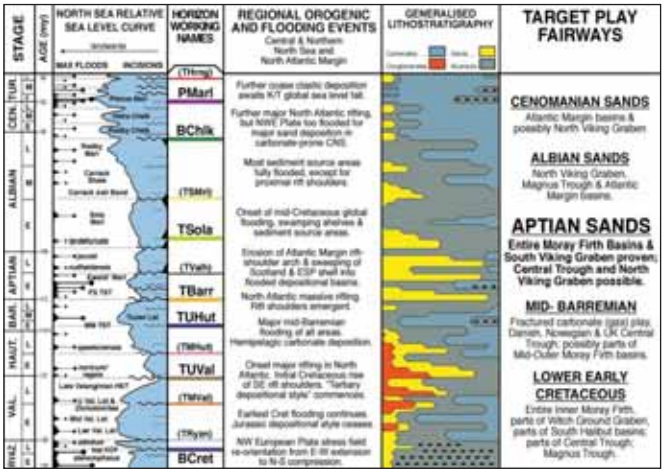

Figure 2: New Lower Cretaceous stratigraphy and potential play fairways identified in this study.

As well as re-appraised tops data, the study also included an analysis of sand presence, shows, test result data and a qualitative assessment of data quality, useful when dealing with wells drilled by many different operators over a 35 year period.

The result is a unique and extremely comprehensive new Lower Cretaceous well database with a consistency and level of detail previously unseen by the industry. Such a powerful database has enabled PGS to undertake a regional interpretation of the key events identified within the Lower Cretaceous, and begin to define, for example, the enigmatic Aptian sand fairway - along with Albian, Barremian and gross earliest Cretaceous intervals - with a higher degree of confidence.

Previously, exploration in the Lower Cretaceous has been limited due to the perception of it being more of a drilling hazard than a viable exploration target: shale-dominated, HPHT – risky and dangerous to drill through or in, difficult to image on seismic, and overshadowed by more attractive targets in the Palaeocene or Jurassic. But with the North Sea becoming ever more mature, these enigmatic sands within the Lower Cretaceous must become more attractive to the bold explorer – and increasingly so with an oil price approaching $150-200/bbl. Having a good quality regional 3D seismic with a high resolution interpretation, backed by a brand new highly consistent well database, offers a unique opportunity to investigate this interval thoroughly despite the long-standing perception that it would be difficult to consistently pick the relatively weak events of the Lower Cretaceous. As can be seen, this is not so (**Figure 3**).

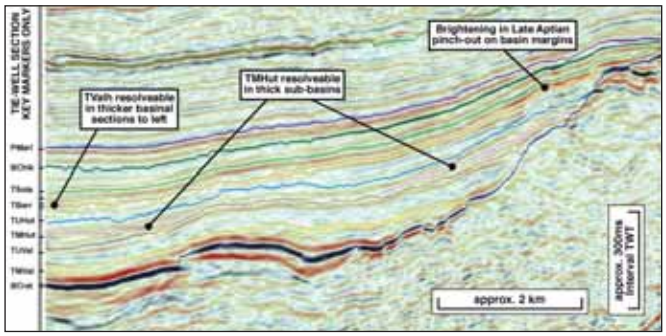

Figure 3: Typical appearance of Lower Cretaceous section in the Central Graben.

For probably the first time a regional picture has emerged, backed by data rather than purely model based. This allows the regional depositional models to be refined, opening up the possibility of identifying new plays and prospects within this hitherto overlooked interval.

Findings

A total of five discrete but basin-wide deposystems have been recognised for the Lower Cretaceous interval. These show considerable translocation with time on both local and regional scales, controlled by episodic transpression and related halokinesis. This results in a correspondingly dramatic switch in sand distribution and a progressive change in the relative importance of local to long distance sediment provenance.

Much of the Lower Cretaceous sedimentation originated from erosion of the extensive rift shoulder which developed as the Atlantic opened in the earliest Cretaceous. Long distance sediment transport is envisaged with these sediments carried in a South Easterly direction into the Moray Firth area and beyond by basin fill and spill across a long gone shelfal area. There are other sediment source areas such as the London-Brabant massif to the south, landmasses to the east and west, and more local Cimmerian highs. Determining the existence and location of these sediment input conduits from the Atlantic margin was a primary objective of the study.

It is known that these depositional patterns are quite different to the earlier Jurassic patterns, and it has become increasingly apparent that they are very similar to later Palaeocene patterns, yet comparatively sand-poor and more difficult to explore as already noted. In order to create a systematic seismo-stratigraphic model for the Central North Sea study area, significant geological intervals comprising the Cenomanian, Albian, Aptian and Barremian intervals have been correlated with the seismic data and new structural surfaces produced, so that a consistent set of depositional models can be now displayed for the Lower Cretaceous (**Figure 4**).

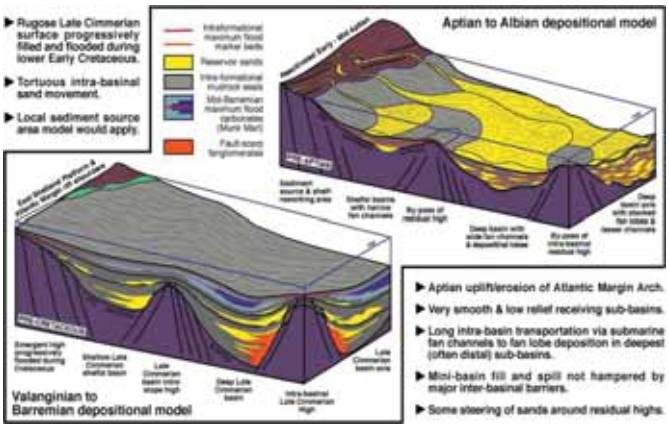

Figure 4: Generalised depositional model for the Albian and Aptian.

The basic TWT interpretation leads naturally into creating isochrons and carrying out basic attribute analysis to help identify the elusive potentially sand rich channels and continually refine the overall depositional models, as well as act as a "sign-post" for further analysis.

Attention in the study has particularly focussed on the Aptian, given the predominance of discoveries in this interval, particularly the giant Britannia Gas Condensate field discovered purely by accident in 1975 but not developed until 1998. However, the Aptian sand fairway has appeared relatively restricted to the Witch Ground Graben/Moray Firth areas, although the Lower Cretaceous isochron as a whole shows a substantial sediment pile in a number of apparently linked Lower Cretaceous sub-basins throughout the Central Graben.

As can be seen in **Figure 5** the key reflectors picked show the progressive onlap onto Cimmerian structures, together with locally developed Aptian thickening and on this example, interesting mounds in the yet-to-be investigated Hauterivian. What is also noteworthy are the localised brightening of the Aptian and Top Upper Hauterivian reflectors where indicated.

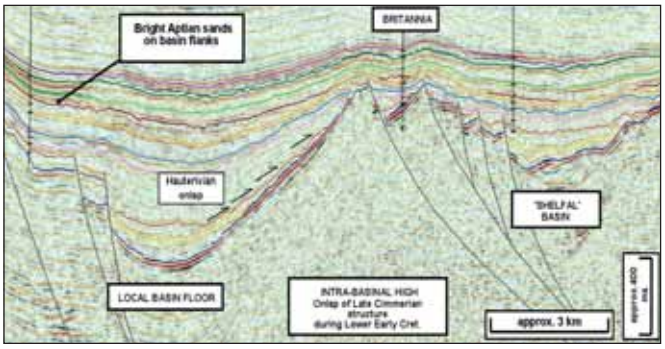

Figure 5: Typical southern Witch Ground Graben profile.

Figure 6 shows the northern Witch Ground Graben, an area traditionally considered to have a thin, commercially insignificant Aptian section. Also shown is the translocation of the basin depocentre during the Aptian, and the existence of a clear late Aptian channel complex, markedly different to the depositional style of the early Aptian. The line also shows the appearance of an early lower Cretaceous fanglomerate derived from the Cimmerian high on the right, and the associated brightening of these Valanginian / Hauterivian reflectors on the left.

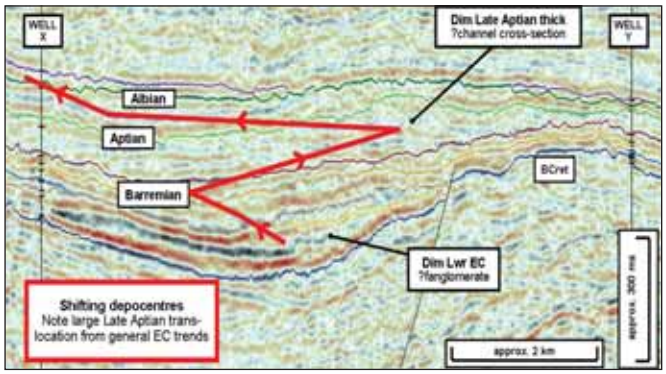

Figure 6: East Central Graben, showing the variation in the Aptian

Channels

As stated, one of the main objectives of the study was to find the channels associated with the proposed long distance transportation, since these are the key to locating good quality but localised channel sands. The seismic response of likely prospective fairways is highly variable; dependant largely on carbonate content, depth to fairways and overpressures. Despite this, there is a high degree of confidence with mapping new fairways into the Eastern Central Graben, and upgrading our current knowledge of the Witch Ground Graben plays.

Picking of such subtle channel features over the long distances involved has proven impossible, but they can be visualised often enough to enable accurate models of their locations and routes to be created with a high degree of confidence (**Figure 7**).

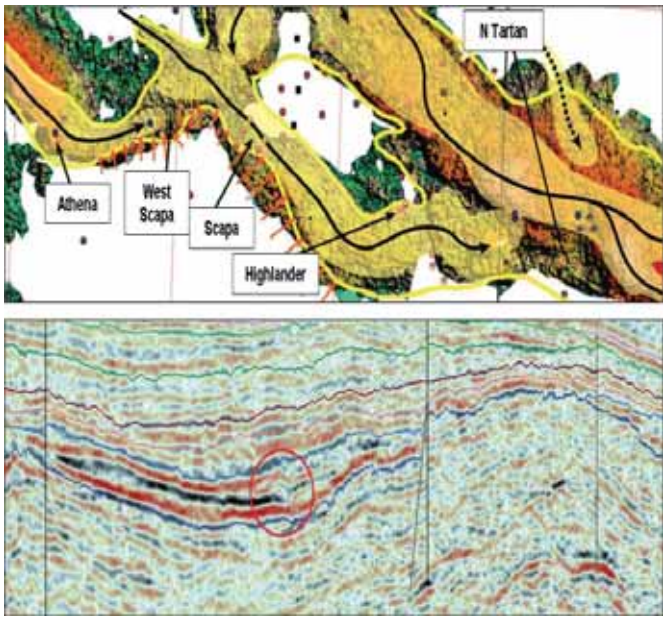

Figure 7: Earliest Cretaceous channels.

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GIS

Generating such a vast amount of data and interpretations creates its own problems in terms of presentation, storage, access and visualisation. To solve this we have adopted a highly user-friendly GIS based "front-end" for the project. As well as the workstation based interpretation and well data, all maps, wells, facies, attributes, summary presentations and so on have been integrated using GIS processes to create a powerful new tool for analysing fairways and helping determine hydrocarbon prospectivity.

GIS stores data in a series of customizable layers, allowing users to display the many and varied datasets in whatever combination they require to answer whatever question they may have, such as Aptian wells with hydrocarbon shows against Aptian isochron (**Figure 8**).

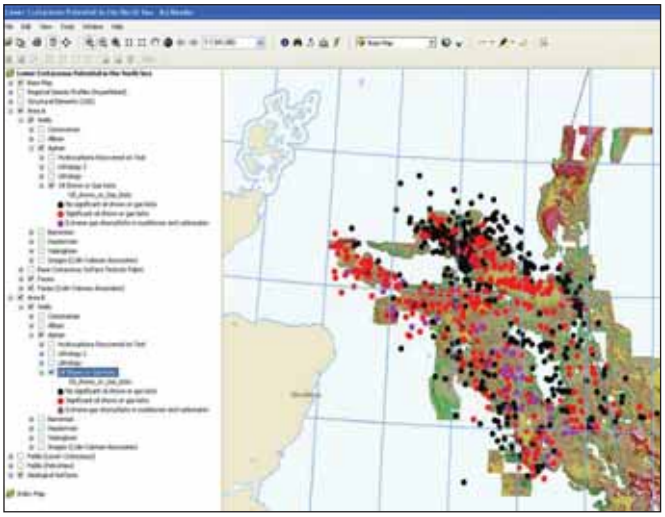

Figure 8: GIS display showing Aptian well shows with the Aptian Isochron.

Other GIS-driven diagnostics include Hauterivian wells which have tested oil against an Upper Hauterivian amplitude extraction with interpreted facies overlain for guidance (**Figure 9**), or simply structural elements which have determined Lower Cretaceous basin geometries. The user has full control and can investigate an area quite thoroughly before moving to the workstation, perhaps to run further attributes on the interpretation to more precisely define a prospect, for example.

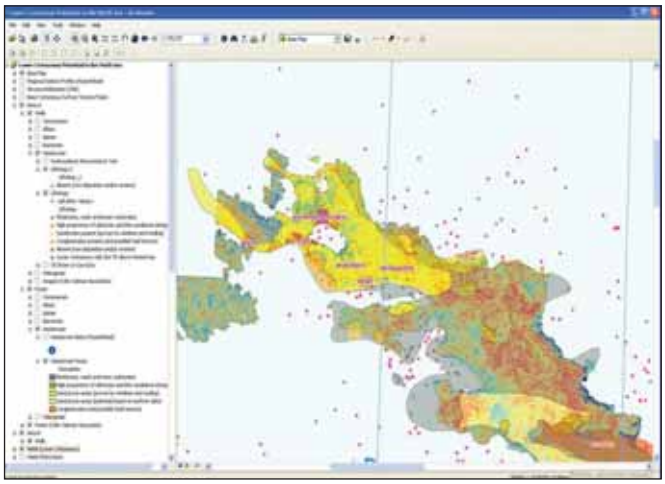

Figure 9: Hauterivian amplitude extraction with well lithologies and inferred facies, with Lower Cretaceous fields also shown.

Conclusions

The PGS MegaSurveys allow visualisation of the subsurface on both a scale and resolution that would have been unimaginable a decade ago. With MegaSurvey data both the regional picture and prospect scale detail is available from a single dataset. Uses can include:

- Evaluating entire basins
- Re-evaluating producing fields
- Re-evaluating held acreage
- Evaluating open acreage

In carrying out the Lower Cretaceous project PGS and COA have built on the potential of the MegaSurvey concept and produced a unique well and seismic based study allowing the Lower Cretaceous to be re-evaluated on a regional scale, using a dataset that would enable prospects to be identified and reviewed at a sufficiently high resolution for block applications to be made. The study can serve as the basis for further detailed work such as basin modelling, potential field modelling, further selected attribute work, and so on. Even in its own right the Lower Cretaceous study can help finally unlock the potential of this overlooked and underexplored play, and is already being employed by applicants in the UKCS 25th round.

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