Exploration histories and future potential: overview

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Abstract: The ‘exploration histories and future potential’ section of the Proceedings is designed to provide new insights for future exploration through leveraging learnings from past experiences. In this regard, the exploration histories of selected plays and fields from the Tertiary through the Palaeozoic of NW Europe are used to illustrate these learnings and to provide a guide to determining future potential. It is well recognized that, from a global perspective, NW Europe possesses world class petroleum systems. However, it is commonly perceived as a mature province for exploration and its future potential depends largely on our ability to understand better the known plays and our creativity to generate new plays. The North Sea region, in this context, benefits from the presence of two super source rocks, in the Kimmeridgian and Westphalian, and a diverse stratigraphy resulting in more than twenty plays from the Tertiary to the Palaeozoic. Historically, on a world-wide basis, the majority of stratigraphic traps have been discovered by serendipity. The wealth of high quality datasets in the North Sea and NW Europe, in combination with new advances in technology, provide an excellent natural laboratory to determine if untested plays and trapping concepts still remain.

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The exploration history of the North Sea plays has been described by Brennand et al. (1998) and Eriksen et al. (2003). These accounts describe specific geological, technological and fiscal triggers in the exploration of the wider North Sea theatre. This section of the Proceedings commences with a global perspective comparing the North Sea exploration history with selected other rift basins world-wide (Spencer et al., this volume).

The next series of papers examines future potential, the ‘Yet to Find’, on a country-by-country basis, incorporating lessons from the past. Different methodologies are adopted in these calculations, ranging from a petroleum systems approach on a basin scale, to prospect summation. In the majority of the determinations of the ‘Yet to Find’, a strong emphasis is placed on known plays – to extrapolate from what is known rather than providing estimates of new play potential. The latter is particularly difficult. The challenge to all those involved in exploration is not to be set in the paradigm of extrapolating from what is known, but to search continually for, and take account of, new plays. The ‘Yet to Find’ is addressed in the UK by papers contributed by Vining et al. (this volume) and Munns et al. (this volume). These assessments are based on well-recognized geostatistical techniques, using a play-based probabilistic approach. Creaming curves are a common methodology to indicate play maturity and can give different perspectives dependent on the criteria upon which plays are defined, i.e. combining certain sub-plays can result in a significantly more mature creaming curve profile than the individual creaming curves of the sub-plays. A similar approach is taken for Norway, by Østvold et al. (this volume) and Blystad & Sandenå (this volume), Denmark by Hemmet (this volume) and The Netherlands by Breuneese et al. (this volume) and Lutgert et al. (this volume). The latter is particularly interesting in that Groningen plays such a significant role.

On a country-by-country basis, the need to have a best estimate of future potential is imperative from a political perspective. However, from a geoscience perspective, the fundamental unit of analysis is the play, and plays cross political boundaries. In the future, given the wealth of data and knowledge in the North Sea, each country assessment will benefit by including cross-border play understandings. For example, the Southern Permian Basin plays include the UK, Netherlands, Germany and Poland, whereas the various Palaeozoic, Mesozoic and Tertiary plays of the Central Graben area include the UK, Norway and Denmark.

It is with this play viewpoint in mind that the remaining papers in this section are, in the most part, placed in descending stratigraphical order, starting with the Tertiary and concluding with the Palaeozoic. In this overall format, however, certain key messages will become evident. First and foremost is that plays are invariably more complex than initially perceived; new understandings can come late in a basin’s history. Secondly, perseverance in exploration can produce valuable results, in some cases very different from initial expectations. Thirdly, the advent of exploration for stratigraphical traps has not yet fully occurred and, lastly, serendipity has played its part: explorers seek one prize and find another. Some of these aspects have been addressed in specific case histories in Hardman (2003) and Dean (1996), with particular reference to fields discovered after previous ‘near misses’. The field- and play-based exploration history papers in this section will be discussed briefly, with these key messages in mind.

Complexity of plays

Starting with the Tertiary, the benefits of integration of multiple disciplines are well illustrated for the Jotun Field (Bergslien et al., this volume), producing some exciting results through the life cycle of exploration, development and production. In contrast to this type of approach to reducing uncertainty, Rodriguez et al. (this volume) describe how the drilling campaign on Tullich Field was designed to understand better the reservoir continuity and connectivity issues. In the Norwegian sector, the Tertiary Alvdalheim discoveries occurred somewhat late on in the play history and a re-visit to the reservoir model of the Heimdal Formation is

discussed by Fitzsimmons et al. (this volume). Finally, in the Tertiary, the continued understanding of the role of injectites in exploration and production (Hurst et al., this volume) clearly illustrates that our fundamental understanding of the controls on play development and its complexity can dramatically change late in a basin’s history. The occurrence of these features in other depositional settings poses significant questions for the future and may re-cast, in some cases, the paradigms of reservoir architecture in certain deep-water depositional systems.

The Late Cretaceous chalk play is also one of the oldest and most prolific in the Norwegian and Danish sectors of the North Sea and may be an emerging play in the UK sector. The challenges surrounding reserves uncertainty are described by Gautier & Kleett (this volume). These challenges are principally trap definition and reservoir productivity. Again, after many years of exploration and production, the chalk play remains invariably more complex than initially perceived; new understandings continue to come late in the basin’s history. Fundamental questions involving trapping mechanisms are, in some cases, still to be resolved (Megson & Tygessen, this volume). At a field scale these issues are discussed by Jakobsen et al. (this volume) for the Valdemar Field. In the search for a better understanding as to how the play works it is imperative to challenge existing paradigms. In this regard the paper by Dennis et al. (this volume) explores concepts of hydrodynamic trapping to provide new insights to some of the observations of the chalk play.

Staying with the carbonate theme and, in particular, the issue of predicting reservoir productivity, Pöppelreiter et al. (this volume) discuss production from the Triassic Muschelkalk carbonates of the NE Netherlands.

Perhaps the play that most emphasizes the better understanding of its complex nature over the past 40 years is the Central North Sea, Jurassic and Triassic high pressure/high temperature (HPHT) play. At a reservoir level, McKie & Audretsch (this volume) address challenges of predicting Triassic reservoir connectivity. A comprehensive chronology of increasing understanding of the HPHT play is summarized by Erratt et al. (this volume). At any one snapshot in time, explorers perceive to have an understanding of the play, only for this understanding to evolve through successes and disappointments with the advent of technology, particularly large-scale 3D seismic surveys, and drilling experiences. The HPHT play illustrates well the first key message: that plays are invariably more complex than initially perceived. It can also illustrate the second key message equally well: new understandings can come late in basin’s history.

Perseverance in exploration

Staying with the HPHT play, the presence of intra-formational seals providing stacked hydrocarbon columns, as shown by recent experiences in the development of the Jade Field (Jones et al., this volume), opens new opportunities for the future of this play. Prediction of the sealing versus leaking nature of faults, both in geological as well as a production time frame, continues to be a challenge. In a different play setting to the HPHT, Corona (this volume) examines fault trap analysis in the Permian Rotliegendes gas play in the Lauwerszee Trough, NE Netherlands. Perseverance in exploring and producing from fault-related traps in the Rotliegendes gas play of the Southern Permian Basin in the Netherlands, Germany and the UK has, over the years, yielded results in some cases very different from initial expectations. A better understanding of the controls on fault seal and leakage would, undoubtedly, unlock new opportunities in the Rotliegendes gas play.

Perseverance in exploration can be illustrated equally by the Early Cretaceous clastic play in the North Sea. This play has been pursued for 40 years. Has its full potential been realized or is it still in the emerging phase? This rhetorical question is discussed at a regional scale by Oakman (this volume) invoking different play models. Similarly, Seldal (this volume) poses the question as to whether the Early Cretaceous would be the next target for exploration in the Barents Sea.

Exploration histories of the Early Cretaceous (Kopervik Formation) play in the UK sector clearly show that perseverance in exploration, using different geological models through time, as an understanding of the play changes, can produce valuable results very different from initial expectations. Wilson et al. (this volume) provide an excellent exploration history of the Kopervik play in the South Halibut Basin, the various lessons learnt and changes in direction on the way, which culminated in the discovery and subsequent development of the Goldeneye Field. A complementary paper, by Argent et al. (this volume), discusses the technical challenges to exploration and development of this play, confirming, from a different prospective, key lessons learnt for future exploration.

A different play in a different basin – this time the Carboniferous of the Southern Permian Basin – echoes the same theme: perseverance in exploration can provide valuable results. Cooper et al. (this volume) provide an example of how a cluster development in the Caister–Murdock (CMS) III area provides the commercial attractiveness for production of this resource. Again, rhetorical questions can be posed: what is the potential of the various Carboniferous plays? What other innovative development concepts can be applied to plays that are not currently commercially viable?

A final example of this message of perseverance in exploration is provided by Richardson et al. (this volume) for the frontier, Palaeozoic East Orkney and Dutch Bank basins. These frontiers have been known for many years and the question as to whether their exploration will provide valuable results has yet to be answered.

Exploration for stratigraphic traps

It is well recognized that stratigraphic traps can provide a promise of large volumes. However, they are invariably high risk opportunities. The largest North Sea discovery in over a decade is a combination structural–stratigraphic trap: the Buzzard Field. Dore & Robbins (this volume) provide an excellent summary of this discovery. Historically, on a world-wide basis, the majority of stratigraphic traps have been discovered by serendipity; explorers seek one prize and find another. This will undoubtedly continue to occur in the future and will provide added excitement to exploration.

Conclusions

The section on ‘exploration histories and future potential’ provides a knowledge base where experiences are shared to set scenarios for future exploration in NW Europe. World class petroleum systems and a diversity of play types underpin this future. Is there a future for stratigraphic traps? Can new plays be generated? The wealth of high quality datasets in combination with new advances in technology provide an excellent natural laboratory in which to seek answers to these questions.

References


