

## Field management

### Introduction and review

M. L. B. MILLER<sup>1</sup> and J. H. MARTIN<sup>2</sup>

<sup>1</sup>*Petroleum Science and Technology Institute, Edinburgh, UK (Present address: Curlew Consulting, Whistlebrae, Braco, Dunblane, Perthshire FK15 9RA, UK)*

<sup>2</sup>*Imperial College of Science, Technology and Medicine, Prince Consort Road, London SW7 2BP, UK (Present address: Reservoir Geological Consultant, 150 Croxted Road, London SE21 8NW, UK)*

This 'Field management' section contains 13 papers focusing specifically on two areas of field evaluation:

- appraisal of complex offshore discoveries;
- management and review of developed fields, both offshore and onshore.

In addition, some 13 field case studies are presented within other sections of these volumes, along with many other briefer references to fields within NW Europe, particularly in the North Sea area (Table 1).

A number of themes can be recognized which reflect recent developments within the industry. The first trend which we

**Table 1.** Cross-references to NW Europe oil and gas fields in *Petroleum Geology of NW Europe: Proceedings of the 4th Conference*

*Note:* Titles/author listings in plain text indicate those papers which contain detailed accounts of individual fields, or specific aspects of these fields. Those listings in italics refer to specific aspects of fields or groups of fields within thematic or regional reviews.

Field	Title	Author
Adda	<i>The Lower Cretaceous chalk play in the Danish Central Trough</i>	<i>Ineson</i>
Alba	<i>Historical overview of Tertiary plays in the UK North Sea</i>	<i>Bain</i>
	The Alba Field: evolution of the depositional model	Newton and Flanagan
Arbroath	<i>Historical overview of Tertiary plays in the UK North Sea</i>	<i>Bain</i>
Balder	Origin of complex mound geometry of Paleocene submarine-fan sandstone reservoirs, Balder Field, Norway	Jenssen <i>et al.</i>
Beryl	<i>Sedimentation of Upper Triassic reservoir in the Beryl Embayment: Lacustrine sedimentation in a semi-arid environment</i>	<i>Dean</i>
	Beryl Field: geological evolution and reservoir behaviour	Robertson
Brent	<i>Jurassic exploration history: a look at the past and the future</i>	<i>Cordey</i>
Britannia	<i>Complex deformation and fluidization structures in Aptian sediment gravity flow deposits of the Outer Moray Firth</i>	<i>Downie and Stedman</i>
Bruce	The Bruce Field	Beckly <i>et al.</i>
Buchan	<i>Genetic sequence stratigraphy for the North Sea Late Jurassic and Early Cretaceous: distribution and prediction of Kimmeridgian–Late Ryazanian reservoirs in the North Sea and adjacent areas</i>	<i>Partington et al.</i>
Caister	<i>Permo-Carboniferous plays of the Silver Pit Basin</i>	<i>Bailey et al.</i>
	The Caister Fields, Block 44/23a, UK North Sea	Ritchie and Pratsides
Clair	Clair appraisal: the benefits of a co-operative approach	Coney <i>et al.</i>
Claymore	<i>Estimation of recoverable reserves: the geologist's job</i>	<i>Corrigan</i>
Clyde	<i>Genetic sequence stratigraphy for the North Sea Late Jurassic and Early Cretaceous: distribution and prediction of Kimmeridgian–Late Ryazanian reservoirs in the North Sea and adjacent areas</i>	<i>Partington et al.</i>
	Clyde: reappraisal of a producing field	Turner
Cormorant	A fundamental reappraisal of the structure of the Cormorant Field and its impact on field development strategy	<i>Demyttenaere et al.</i>
Crawford	<i>Low angle faulting in the Triassic of the South Viking Graben: implications for future correlations</i>	<i>Morgan and Cutts</i>
Dan	<i>Geological aspects of horizontal drilling in chalks from the Danish sector of the North Sea</i>	<i>Fine et al.</i>
Drake	<i>Paleocene reservoirs of the Everest trend</i>	<i>O'Connor and Walker</i>
Dunlin	<i>Estimation of recoverable reserves: the geologist's job</i>	<i>Corrigan</i>
Eakring Dukeswood	The Eakring Dukeswood oil field: an unconventional technique to describe a field's geology	Storey and Nash
Embla	The Embla Field	<i>Knight et al.</i>
Erskine	<i>Overpressures in the Central North Sea: implications for trap integrity and drilling safety</i>	<i>Gaarenstroom et al.</i>
Everest	<i>Historical overview of Tertiary plays in the UK North Sea</i>	<i>Bain</i>
	<i>Paleocene reservoirs of the Everest trend</i>	<i>O'Connor and Walker</i>
F/15-A	F/15-A: A Triassic gas field on the eastern limit of the Dutch Central Graben	Fontaine <i>et al.</i>
Forth	<i>Historical overview of Tertiary plays in the UK North Sea</i>	<i>Bain</i>
Forties	<i>Historical overview of Tertiary plays in the UK North Sea</i>	<i>Bain</i>
	<i>Estimation of recoverable reserves: the geologist's job</i>	<i>Corrigan</i>
Franklin	<i>Overpressures in the Central North Sea: implications for trap integrity and drilling safety</i>	<i>Gaarenstroom et al.</i>

Table 1. (continued)

Field	Title	Author
Frigg	<i>Historical overview of Tertiary plays in the UK North Sea</i>	Bain
Gannet	<i>Historical overview of Tertiary plays in the UK North Sea</i>	Bain
Groningen	<i>The Rotliegend in northwest Germany, from frontier to fairway</i>	Burri et al.
Gryphon	<i>Historical overview of Tertiary plays in the UK North Sea</i>	Bain
	The geology of the Gryphon Oil Field	Newman et al.
Gyda	<i>Genetic Sequence Stratigraphy for the North Sea Late Jurassic and Early Cretaceous: distribution and prediction of Kimmeridgian–Late Ryazanian reservoirs in the North Sea and adjacent areas</i>	Partington et al.
	<i>Structural controls on the Late Jurassic age shelf system, Ula Trend, Norwegian North Sea</i>	Stewart
Heather	<i>Estimation of recoverable reserves: the geologist's job</i>	Corrigan
Heron	Overpressures in the Central North Sea: implications for trap integrity and drilling safety	Gaarenstroom et al.
Hutton	Silicate mineral authigenesis in the Hutton and NW Hutton fields: implications for sub-surface porosity development	McAulay et al.
	<i>Estimation of recoverable reserves: the geologist's job</i>	Corrigan
Hyde	Hyde: a proposed development in the Southern North Sea using horizontal wells	Steele et al.
Machar	<i>Historical overview of Tertiary plays in the UK North Sea</i>	Bain
	The evolution of the fractured chalk reservoir: Machar Oilfield, UK North Sea	Foster and Rattey
Maggie	<i>Paleocene reservoirs of the Everest trend</i>	O'Connor and Walker
Magnus	<i>Genetic sequence stratigraphy for the North Sea Late Jurassic and Early Cretaceous: distribution and prediction of Kimmeridgian–Late Ryazanian reservoirs in the North Sea and adjacent areas</i>	Partington et al.
	<i>Estimation of recoverable reserves: the geologist's job</i>	Corrigan
Marnock	<i>Salt control on Triassic reservoir distribution, UKCS Central North Sea</i>	Smith et al.
	Overpressures in the Central North Sea: implications for trap integrity and drilling safety	Gaarenstroom et al.
Maureen	<i>Historical overview of Tertiary plays in the UK North Sea</i>	Bain
Meillon-Saint Faust	Meillon-Saint Faust gas field, Aquitaine basin: structural re-evaluation aids understanding of water invasion	Haller and Hamon
Miller	<i>Genetic Sequence Stratigraphy for the North Sea Late Jurassic and Early Cretaceous: distribution and prediction of Kimmeridgian–Late Ryazanian reservoirs in the North Sea and adjacent areas</i>	Partington et al.
	Miller Field: reservoir stratigraphy and its impact on development	Garland
Morecambe	The use of dipmeter logs in the structural interpretation and palaeocurrent analysis of Morecambe Fields, East Irish Sea Basin	Cowan et al.
	<i>The tectonic history of the East Irish Sea Basin with reference to the Morecambe Fields</i>	Knipe et al.
Murchison	<i>Tectonic evolution and structural styles of the East Shetland Basin</i>	Lee and Hwang
	<i>Permo-Carboniferous plays of the Silver Pit Basin</i>	Bailey et al.
North Morecambe	<i>The tectonic history of the East Irish Sea Basin with reference to the Morecambe Fields</i>	Knipe et al.
	The geology of the North Morecambe Gas Field, East Irish Sea Basin	Stuart
NW Hutton	Silicate mineral authigenesis in the Hutton and NW Hutton fields: implications for sub-surface porosity development	McAulay et al.
	<i>Estimation of recoverable reserves: the geologist's job</i>	Corrigan
Piper	<i>Estimation of recoverable reserves: the geologist's job</i>	Corrigan
Puffin	Overpressures in the Central North Sea: implications for trap integrity and drilling safety	Gaarenstroom et al.
Ravenspurn North	Structural and sedimentological controls on diagenesis in the Ravenspurn North gas reservoir, UK Southern North Sea	Turner et al.
Saltire	Appraisal geology of the Saltire Field, Witch Ground Graben, North Sea	Casey et al.
Salzwedel	<i>The Rotliegend in northwest Germany, from frontier to fairway</i>	Burri et al.
Skua	Overpressures in the Central North Sea: implications for trap integrity and drilling safety	Gaarenstroom et al.
	<i>Paleocene reservoirs of the Everest trend</i>	O'Connor and Walker
Sleipner Ost	Prediction of large-scale communication in the Smørbukk fields from strontium fingerprinting	Stølum et al.
Smørbukk		
Snorre	The structural evolution of the Snorre Field and surrounding areas	Dahl and Solli
Sohlingen	<i>The Rotliegend in northwest Germany, from frontier to fairway</i>	Burri et al.
Tartan	<i>Estimation of recoverable reserves: the geologist's job</i>	Corrigan
Thistle	<i>Estimation of recoverable reserves: the geologist's job</i>	Corrigan
Tiffany et al.	The interaction of structure and sedimentary process controlling deposition of the Upper Jurassic Brae Formation Conglomerate Block 16/17, North Sea	Cherry
Tyra	<i>Geological aspects of horizontal drilling in chalks from the Danish sector of the North Sea</i>	Fine et al.
Ula	<i>Genetic Sequence Stratigraphy for the North Sea Late Jurassic and Early Cretaceous: distribution and prediction of Kimmeridgian–Late Ryazanian reservoirs in the North Sea and adjacent areas</i>	Partington et al.
	<i>Structural controls on the Late Jurassic age shelf system, Ula Trend, Norwegian North Sea</i>	Stewart
Valdemar	<i>Geological aspects of horizontal drilling in chalks from the Danish sector of the North Sea</i>	Fine et al.
	<i>The Lower Cretaceous chalk play in the Danish Central Trough</i>	Ineson
Waalwijk	<i>A review of the Triassic play in the Roer Valley Graben, SE onshore Netherlands</i>	Winstanley
Wytych Farm	Wytych Farm oilfield: deterministic reservoir description of the Triassic Sherwood Sandstone	Bowman et al.

note is the industry's ability to contain risk through better understanding of the technical problems, with improved technology able to provide greater flexibility in development planning. Technical disciplines are communicating better and shorter management chains bring the decision-makers closer to the issues.

Several papers describe development prospects whose appraisal history has been prolonged by contradictory delineation well results giving wild fluctuations in anticipated reserves. Other prospects were initially believed to be too small, complex, or poorly productive to warrant development, and two papers consider the consequences of inadequate appraisal. A typical example of fluctuating reserve estimates is described in 'The evolution of a fractured chalk reservoir—Machar Oil Field, UK North Sea' by **Foster and Rattay**. This field was discovered in 1976, but is only now ready for development following a long appraisal history during which the difficulties in understanding the reservoir distribution in a complex chalk system were overcome. High pressure, poor seismic resolution, structural complexities and ill-defined reservoir stratigraphy combine to provide major reserve uncertainties reviewed in the discussion of 'The Embla Field' in the Norwegian sector by **Knight et al.** The impact of these uncertainties on the range of development options is clearly shown.

Benefits of new technology and improved communication are a theme of the paper by **Coney et al.** 'Clair appraisal: the benefits of a co-operative approach'. Activity in the Clair area has recently been boosted by the technical success of a high angle well which penetrated a productive fracture zone. 'Hyde: a proposed development in the Southern North Sea using horizontal wells' by **Steele et al.** illustrates the increasing use being made of horizontal wells to produce from thin Rotliegendes dune sands interbedded with thick low permeability fluvial and lacustrine sediments. This technique will also be used in the development of F/15-A, a Triassic gas field on the eastern limit of the Dutch Central Graben (**Fontaine et al.**, Triassic Session).

**Turner** in 'Clyde: reappraisal of a producing field' shows how a major field review following some disappointing early development wells went on to form the basis for future development drilling. In our own opinion, external pressures appear to have compromised the original appraisal programme. Caution during field appraisal is perhaps warranted in view of conclusions drawn by **Corrigan** in 'Estimation of recoverable reserves: the geologist's job'. His review of published annual reserve estimates for UK sector fields indicates that structural complexity is the main reason for disappointing field performance particularly in the East Shetland Basin, whereas Paleocene fan fields (Forties Field being the prime example) have outperformed initial expectations.

It appears from many of the papers presented in these volumes as a whole (Table 1) that the lessons are being learnt. Several authors describe the care that is going into the reservoir description, in particular the detailed sedimentological studies required to delineate the Tertiary structural/stratigraphic traps of the Central North Sea, such as Balder (**Jenssen et al.**, Tertiary Session), Alba (Newton and Flanagan, Tertiary Session) and Everest (O'Connor and Walker, Tertiary Session). Others evaluate structural controls on field performance, including Cormorant (**Demyttenaere et al.**, Structural styles Session), Snorre (Dahl and Solli, Structural styles Session) and Morecambe (**Cowan et al.**, Irish Sea basins Session).

Structural complexity is also one of the main features of 'The Bruce Field'. **Beckly et al.** cite fault block compartmentalization as the main reason for an extreme range of initial fluid contacts and conclude, realistically, that final elucidation of communication will not be possible until after production has commenced. Reservoir connectivity problems are also

addressed by **Stølum et al.** who, in their paper 'Prediction of large-scale communication in the Smørbukk fields from strontium fingerprinting', apply new analytical techniques to assess fluid connectivity over geological time. This novel approach appears worthy of additional testing against observed production history in developed fields.

Turning now to the management of producing fields, 'Beryl Field: geological evolution and reservoir behaviour' by **Robertson** illustrates some of the background to an understanding of post-production fluid migration in a structurally complex setting which has enabled the operator to manage an efficient depletion programme through successive drawdown, gas injection and water injection programmes. The future use of horizontal wells has been mentioned above, but of course horizontal drilling has been refined into effective standard development procedure for many fields worldwide, no more so than in Danish offshore chalk fields. **Fine et al.** in 'Geological aspects of horizontal drilling in chalks from the Danish sector of the North Sea' discuss the advances in operational production geology that have made drilling of record-breaking horizontal hole segments possible in low permeability chalks. The value of 'real time' wellsite biostratigraphy in 'steering' holes to within a narrow target tolerance is clearly established.

Although discussion of offshore fields dominates these volumes, one should not forget the importance of onshore development in NW Europe. Results of development drilling of the main reservoir of the largest onshore oil field in the region are briefly described in 'Wytch Farm oilfield: deterministic reservoir description of the Triassic Sherwood Sandstone' by **Bowman et al.** Additional development well data have enabled the operator to replace an earlier stochastic model with a hybrid model which better represents the overall layering observed in the field. Structural complexity is, of course, not confined to the North Sea. The need for interactive geological and engineering reservoir modelling even relatively late in the lifetime of a field (the 'end game') is also illustrated by 'Meillon-Saint Faust gas field, Aquitaine basin: structural re-evaluation aids understanding of water invasion'. In this paper **Haller and Hamon** indicate how geological appreciation of a fractured reservoir improves its management and may extend its producing life. 'The Eakring Dukeswood oil field: an unconventional technique to describe a field's geology' by **Storey and Nash** describes how production history and water breakthrough trends were used effectively to reconstruct a geological model for a recently abandoned field, developed originally with very little dedicated geological information gathering. Despite this major drawback, the authors not only explain past field history but suggest also that parts of the reservoirs remain poorly swept.

The increasing maturity of the NW Europe petroleum province is illustrated by the number of papers in these volumes which describe regional or sub-regional exploration potential based on evaluations of proven and developed fields. Onshore, the Triassic of the Roer Graben is reviewed in the light of data from the Waalwijk Field by Winstanley (Triassic Session), while Burri *et al.* (Permo-Carboniferous Session) show how the more subtle traps in the Rotliegend of northwest Germany could only be evaluated following close examination of the diagenetic history of the Groningen, Salzwedel and Sohlingen fields. Offshore and further north, the Ula and Gyda fields provide both regional sequence stratigraphic control for the late Jurassic (**Partington et al.** (Jurassic Session)) and structural evidence of the reservoir distribution which has led to the discovery of a number of adjacent hydrocarbon pools (**Stewart** (Jurassic Session)).

Apart from the technical aspects of appraisal and development, papers included within this 'Field management' section highlight consistently not only the close interaction needed between production geology and geophysics, but also between

geoscientist, petroleum engineer and management. A spirit of openness appears to be present. The co-operative approach to appraisal of the Clair discovery, for example, has led to a new appraisal drilling programme in this previously dormant prospect, and development of the Bruce Field is now underway

following a similar co-operative approach. Finally, the frank discussion of the risks inherent in plans to bring the Embla Field on stream will also be of interest to all oil company technical and managerial staff contemplating development of marginal or complex fields.