Basin Modelling: Practice and Progress

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A. C. MORTON
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# Basin Modelling: Practice and Progress

EDITED BY

S. J. DÜPPENBECKER
BP Exploration Inc., Houston, Texas, USA

&

J. E. ILIFFE
PGS Tigress (UK) Ltd, Aberdeen, UK
(Present address: Conoco Inc., Houston, Texas, USA)

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# Preface

Petroleum exploration in frontier to developing regions is model driven, whether the model is comprised of ideas in a geoscientist's head, or of results of numerical simulations investigating several scenarios that test the boundaries of possibility. Modelling is a valuable process of risk reduction in exploration prospectivity assessment, and an area which has significant room for risk reduction in new technologies, or in better practices with existing technologies.

The impact of basin modelling on the exploration business is on risking source effectiveness, and by providing the timing framework for petroleum generation, migration and reservoir/trap formation. The reconstruction of the geological evolution of a sedimentary basin, and numerical quantification of this information, is now considered to add value. Insight into the development and understanding of a basin that develops during a basin modelling study provides as much value as the final numerical results.

The objective of this volume is to focus for the first time on the application of basin modelling tools to real problems, and to share experiences as to which techniques have worked and which have not. With great regret we have had to reject several excellent contributions related to other themes in order to adhere to this concept. We have striven for a balance between how greater understanding of some of the processes and parameters could affect model results, and the application of software and techniques to solve particular questions posed about different basins. Although the contents of this volume do not reflect this as we would have wished, all the papers make a valuable contribution to the future of basin modelling.

In the vanguard, **Waples** rises to the unenviable task of providing a keynote paper entitled 'Basin modelling: how well have we done?'. This reflective analysis demonstrates the foundation of our present level of understanding, and outlines areas where we should venture forth.

Some of the basic concepts of basin modelling that have fallen into general acceptance over the past two decades are fundamentally challenged by the papers in this volume. **Giles *et al.*** revisit the concepts employed for calculating compaction, and their incorporation of physical, thermal and chemical processes into a more realistic behaviour is highly illuminating. Similarly, **Okui *et al.*** quantified hydrocarbon expulsion from shale source rocks as a function of porosity and permeability in the laboratory. From this they derived an expulsion model that is more representative of argillaceous rocks, rather than the typical values normally used for saturation thresholds, originally derived from reservoir rocks. These fundamental changes in our understanding of the real physical processes have important connotations for the results of our basin simulations in terms of pressure, temperature, maturity and phase of hydrocarbons produced from the source rock.

The enigma of overpressure formation is elucidated by **Waples & Couples**, who eloquently clarify the interactions of rock properties with the sensitive rate-determining processes that take place during compaction. **Tokunaga *et al.*** quantified these rate-controlling dynamic shale rock properties in the laboratory and investigated their effects on the physical processes by numerical modelling. The overpressure theme is continued with **Darby *et al.***'s paper on pressure simulation in 1D and 2D simulations. **Throndsen & Wangen**, also take up the question of our level of understanding of the 3D volume when our problems are simply constructed in one or two dimensions. Their three-dimensional simulator examples indicate the importance of modelling the system as a whole.

The importance of truly integrated multidisciplinary projects that represent the vital technical core of exploration decisions is demonstrated in the application papers by Symington *et al.*, Ho *et al.*, Hegre *et al.*, Shegg & Leu and Archard *et al.* **Archard *et al.*** assess uplift using a variety of techniques in a very complex basin history. The uplift and erosion analysis theme is shown to be crucial to assessing geothermal gradients and temperature histories in a compressive tectonic regime by **Schegg & Leu**. Both Archard *et al.* and Shegg & Leu describe pragmatic approaches that use various datasets to determine the same unknown parameters, and handle the uncertainties in their data and techniques. **Hegre *et al.*** present an attractive set of pyrolysis data that show an unexpected variability. Their problem is typical of that of the modeller in that several explanations might be valid, but which one is true? **Symington *et al.*** present an excellent example of an integrated multidisciplinary approach to date and quantify trap charge from the kitchen regions. The strength of their analysis is in the verification of the predictions from their 2D and 3D simulators using a wide variety of data types.

The reflective vein of the volume is continued by **Ho *et al.*** who report a comparative study of pre-drilling and post-drilling maturity predictions and results. They show how well they did in the early 1980s, using seismic velocities to predict thermal

conductivity for their models, compared with the results using the more sophisticated software of the 1990s. Their approach shows the importance of information within the actual seismic data on which we base our models.

Rather than providing a unique solution, basin modelling allows investigation of a range of geological models and hypotheses and the selection of the most likely. The importance of sensitivity analysis and recognition of uncertainty in input datasets is highlighted by **Thomsen**, using a probabilistic technique, and by **Gallagher & Morrow** using numerical inversion techniques to constrain heat flow histories. So, how well can we do most of the time?

What remains clear from this volume is that modelling will continue to evolve as a joint effort between technological advances in the data acquisition, model building and simulation software, along with more rigorous quantification and understanding of the thermodynamics of the rock and fluid properties. We are rapidly approaching the age of true three-dimensional models, where we will likely discover new sets of interdependencies, new uncertainties to unravel – in particularly around fluid migration, and new calibrants for our models.

## Acknowledgements

The editors gratefully acknowledge the work of the reviewers for the papers in this book, and we also wish to thank all those presenters who contributed to the success of the conference which gave rise to this volume. We reserve a special thanks to those who have made the time and effort to contribute to this stimulating volume.