Preface

This book is about the design and construction of subsurface reservoir models. In the early days of the oil industry, oil and gas production was essentially an engineering activity, dominated by disciplines related to chemical and mechanical engineering. Three-dimensional (3D) geological reservoir modelling was non-existent, and petroleum geologists were mostly concerned with the interpretation of wire-line well logs and with the correlation of geological units between wells.

Two important technological developments – computing and seismic imaging – stimulated the growth of reservoir modelling, with computational methods being applied to 2D mapping, 3D volumetric modelling and reservoir simulation. Initially, computational limitations meant that models were limited to a few tens of thousands of cells in a reservoir model, but by the 1990s standard computers were handling models with hundreds of thousands to millions of cells within a 3D model domain.

Geological, or 'static' reservoir modelling, was given a further impetus from the development of promising new geostatistical techniques – often referred to as pixel-based and object-based modelling methods. These methods allowed the reservoir modeller to estimate inter-well reservoir properties from observed data points at wells and to attempt statistical prediction.

3D reservoir modelling has now become the norm, and numerous oil and gas fields are developed each year using reservoir models to determine in-place resources and to help predict the expected flow of hydrocarbons. However, the explosion of reservoir modelling software packages and associated geostatistical methods has created high expectations but also led to periodic disappointments in the reservoir modeller's ability (or failure) to predict reservoir performance. This has given birth to an oft quoted mantra "all models are wrong."

This book emerged from a series of industry and academic courses given by the authors aimed at guiding the reservoir modeller through the pitfalls and benefits of reservoir modelling, in the search for a reservoir model design that is useful for forecasting. Furthermore, geological reservoir modelling software packages often come with guidance about which buttons to press and menus to use for each operation, but very little advice on the objectives and limitations of the model algorithms. The result is that while much time is devoted to model building, the outcomes of the models are often disappointing.

Our central contention in this book is that problems with reservoir modelling tend not to stem from hardware limitations or lack of software skills but from the approach taken to the modelling – the model design. It is essential to think through the design and to build *fit-for-purpose* models that meet the requirements of the intended use. In fact, all models are *not* wrong, but in many cases models are used to answer questions which they were not designed to answer.

We cannot hope to cover all the possible model designs and approaches, and we have avoided as much as possible reference to specific software modelling packages. Our aim is to share our experience and present a generic approach to reservoir model design. Our design approach is geologically based – partly because of our inherent bias as geoscientists – but mainly because subsurface reservoirs are composed of rocks. The pore space which houses the "black gold" of the oil age, or the "golden age" of gas, has been constructed by geological processes – the deposition of sandstone grains and clay layers, processes of carbonate cementation and dissolution, and the mechanics of fracturing and folding. Good reservoir model design is therefore founded on good geological interpretation.

There is always a balance between probability (the outcomes of stochastic processes) and determinism (outcomes controlled by limiting conditions). We develop the argument that deterministic controls rooted in an understanding of geological processes are the key to good model design. The use of probabilistic methods in reservoir modelling without these geological controls is a poor basis for decision making, whereas an intelligent balance between determinism and probability offers a path to model designs that can lead to good decisions.

We also discuss the decision making process involved in reservoir modelling. Human beings are notoriously bad at making good judgements – a theme widely discussed in the social sciences and behavioural psychology. The same applies to reservoir modelling – how do you know you have a fit-for-purpose reservoir model? There are many possible responses, but most commonly there is a tendency to trust the outcome of a reservoir modelling process without appreciating the inherent uncertainties.

We hope this book will prove to be a useful guide to practitioners and students of subsurface reservoir modelling in the fields of petroleum geoscience, environmental geoscience, CO_2 storage and reservoir engineering – an introduction to the complex, fascinating, rapidly-evolving and multidisciplinary field of subsurface reservoir modelling.

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