Petroleum Geoscience

Knut Bjørlykke
Editor

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From Sedimentary Environments to Rock Physics

Second Edition

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Preface

The second edition of Petroleum Geoscience is an updated and corrected version of the first edition from 2010 and there are also four new chapters.

Petroleum geology and geophysics are not well-defined academic subjects. They include many different aspects of the Earth sciences which are used in petroleum exploration and production.

Nearly all types of insight can in some cases be useful in petroleum exploration and production, but there are some disciplines that are most relevant. Since petroleum is formed and for the most part hosted in sedimentary rocks, sedimentology is critical. Palaeontology is important for dating rocks, and carbonate reservoirs may consist mostly of fossils. Structural geology and basin analysis are also vital for reconstructing the migration and trapping of petroleum. Geochemistry and petroleum chemistry are also important. About 50% of the geoscientists in the petroleum industry are involved with production rather than exploration and we have added a chapter on reservoir modelling written by experts from Statoil Norway.

Geophysical methods are essential for logging and seismic exploration, and recently electromagnetic methods have also been more commonly used in exploration and production. This is covered in a new chapter. We have also added a chapter on CCS (Carbon Capture and Storage). The chapter on well logging has been rewritten and is now more comprehensive.

Most universities do not offer specific courses in petroleum geology/geophysics and only a few have Masters or PhD programmes in this field. Oil companies therefore recruit many geologists with little training in these subjects.

In this book, we have tried to give a basic introduction to disciplines relevant to petroleum exploration and we have also included some aspects of petroleum production and modelling.

Since so many different disciplines are included in this book, it is clear that it has not been possible to make in-depth treatments of all of these. This book provides a relatively condensed and precise presentation of the basic theories and facts in each subject and it was therefore necessary to limit the number of field examples and cases.

We have attempted to write a book which requires only a limited background in geology and geophysics. Some of the chapters are therefore relatively basic, but others are more advanced and we have then included more discussion and references to original research papers. Each chapter is written as a separate contribution and

there may be some degree of overlap between them to avoid too much cross reference to other chapters.

Petroleum geology and geophysics are applied disciplines and practical experience is critical. A separate chapter on petroleum exploration is written by a geologist with 40 years of experience from the Norwegian Continental shelf (Hans Rønnevik).

The Norwegian Continental Self (NCS) has been explored for nearly 50 years and data from wells and seismic surveys is very well documented through the Norwegian Petroleum Directorate and is accessible through their home page (www.npd.no). They also have a very large collection of cores.

References to the original literature had to be limited because of the wide range of disciplines. In the past, textbooks often included very extensive lists of references which were very useful when searching for relevant literature. With the electronic databases available now, it is easy to search for relevant references and new textbooks.

In this textbook, we have tried to bridge the gap that often seems to exist between geophysical and geological disciplines and there is also an emphasis on sediment compaction, fluid flow and rock physics. The skills required for a petroleum geologist have changed greatly over the years. Traditionally the main task was to identify reservoir rocks, structures with closure and the proximity of a mature source rock. We are running out of "the easy to find" and "easy to produce" oil and gas, and exploration and production technology is becoming more advanced. It is now possible to produce oil and gas from source rocks (shales) and not only what has migrated into a reservoir rock. This has increased the world's petroleum reserves very significantly in recent years. In North America, shale gas and shale oil production has increased and has lowered the gas price also internationally.

Production of unconventional oil (tar sand, oil shale) and also tight gas reservoirs and gas shale requires a stronger background in mineralogy, chemistry and physics.

The geophysical methods have become increasingly sophisticated and it is now often possible to detect the presence of gas and oil prior to drilling based on seismic data. Electromagnetic methods that were primarily used in mineral prospecting are also used to find oil. As conventional oil is becoming more scarce, more geologists are becoming involved with exploration and production of heavy oil, oil shales and shale gas. Utilization of these resources may be environmentally more problematic than conventional oil and gas and tends to cause increased CO_2 emission during production.

This requires a stronger background in the chemistry and physics of petroleum and also in mineralogy and rock mechanics (rock physics). Physical and chemical modelling is also very important.

Even if alternative sources of energy are being developed, the world will require fossil fuels for several decades. It is a great challenge to limit the environmental consequences of the production and use of fossil energy.

Until sufficient low-cost renewable energy is available, geoscientists can contribute to efficient exploration and production of oil and gas, reducing pollution and CO_2 emissions as much as possible. They may also engage in developing carbon storage.

Much of the theoretical basis is the same for environmental geology and petroleum geology.

Capturing and storage of CO_2 from fossil fuels in the subsurface (CCS) require very much the same skills as production of oil and gas.

We hope that this book will be of some use also for geoscientists who work outside the petroleum industry.

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Oslo, Norway Knut Bjørlykke

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