

Petroleum Resources

with Emphasis on Offshore Fields

WIT*PRESS*

WIT Press publishes leading books in Science and Technology.

Visit our website for the current list of titles.

www.witpress.com

WIT*eLibrary*

Home of the Transactions of the Wessex Institute, the WIT electronic-library provides the international scientific community with immediate and permanent access to individual papers presented at WIT conferences. Visit the WIT eLibrary at <http://library.witpress.com>

Petroleum Resources

with Emphasis on Offshore Fields

O.T. Gudmestad

University of Stavanger, Norway

A.B. Zolotukhin

Gubkin Russian State University of Oil and Gas, Moscow, Russia

E.T. Jarlsby

PETRAD, Stavanger, Norway

WITPRESS Southampton, Boston



O.T. Gudmestad
University of Stavanger, Norway

A.B. Zolotukhin
Gubkin Russian State University of Oil and Gas, Moscow, Russia

E.T. Jarlsby
PETRAD, Stavanger, Norway

Published by

WIT Press

Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK
Tel: 44 (0) 238 029 3223; Fax: 44 (0) 238 029 2853
E-Mail: witpress@witpress.com
<http://www.witpress.com>

For USA, Canada and Mexico

WIT Press

25 Bridge Street, Billerica, MA 01821, USA
Tel: 978 667 5841; Fax: 978 667 7582
E-Mail: infousa@witpress.com
<http://www.witpress.com>

British Library Cataloguing-in-Publication Data

A Catalogue record for this book is available
from the British Library

ISBN: 978-1-84564-478-9

Library of Congress Catalog Card Number: 2009934443

*The texts of the papers in this volume were set
individually by the authors or under their supervision.*

No responsibility is assumed by the Publisher, the Editors and Authors for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. The Publisher does not necessarily endorse the ideas held, or views expressed by the Editors or Authors of the material contained in its publications.

© WIT Press 2010

Printed in Great Britain by MPG Books Group, Bodmin and King's Lynn.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the Publisher.

Biographies



Professor Ove Tobias Gudmestad has been adjunct professor at the University of Stavanger since 1994 and, from 2008, full professor of Marine Technology at the University of Stavanger, Norway.

Gudmestad has experience from engineering, research and projects in Statoil from 1975 to 2008. His offshore-related experience includes pipeline design, offshore structures design, arctic engineering and field development studies. He has management experience from several research projects, concept development studies and engineering tasks.

Gudmestad has published a number of papers and filed several patent applications. He gained an MSc in applied mathematics from the University of Tromsø, Norway in 1973 and a PhD in hydrodynamics from the University of Bergen in 1985. For

two years he studied at Massachusetts Institute of Technology, USA.

Since 2005, he has also been adjunct professor in arctic offshore civil engineering at The Norwegian University of Science and Technology in Trondheim. The Gubkin Russian State University of Oil and Gas in Moscow and the Murmansk State Technical University awarded him honorary doctorate degrees in 2002 and 2008 respectively. He is a Member of the Norwegian Academy of Technological Sciences and a Fellow of Royal Institution of Naval Architects, UK.

Professor Anatoly Zolotukhin holds the position of Deputy Rector on International Affairs of the Russian State Gubkin University of Oil and Gas (Moscow, Russia). He holds a MS degree in petroleum engineering (1969), MS degree in mathematics (1976), PhD in fluid mechanics (1973) and a Doctor of Science degree in reservoir engineering (1990). He has more than 30 years of academic and working experience in areas of reservoir and production engineering, EOR/IOR methods, multiphase flow of fluids in porous media and application of different approaches to reservoir characterization, evaluation of reserves, production forecast and field development modelling. Anatoly B. Zolotukhin is an author and co-author of 12 books and more than 100 articles.



From 1999 till 2004 Anatoly Zolotukhin worked in Statoil as a project manager, and from 2004 until 2008 – as a Technical Director of Statoil representative office in Moscow, Russia.

Anatoly Zolotukhin is a member of the Russian Academy of Natural Sciences.

In addition to his main job he holds several other positions:

- Professor International at Stavanger University (Stavanger, Norway)
- Doctor Honoris Causa, Murmansk State Technical University (Murmansk, Russia)
- Doctor Honoris Causa, Arkhangelsk State Technical University (Murmansk, Russia)
- Vice-President of the World Petroleum Council (since 2008)
- Member of the Academic Council of the European Energy Forum (EUREF) Institute (since 2008)



Dr Erik T. Jarlsby holds a Lic.oec. degree in international economics from the University of St.Gallen, Switzerland, and a PhD in international business from the University of Twente, Netherlands, with as doctoral dissertation on hydrocarbon markets. He has worked for Mobil, Statoil and Borealis, holding professional and managerial positions in field development analysis, NGLs trading and petrochemical feedstock supply. He has lectured in numerous countries on business strategy, petroleum downstream & natural gas issues and project economic analysis. Since 2002, Dr Jarlsby works as a consultant and lecturer through his company Erik Jarlsby AS based in Stavanger, Norway. He is a regular contributor to the PETRAD courses on petroleum development and resource management.

Table of Contents

Preface	ix
Introduction	1
1 The geology of petroleum resources	3
2 Reservoir and production engineering	19
3 Drilling, well design and well completion	51
4 Flow assurance	77
5 Processing requirements in oil and gas production	89
6 Hydrocarbon offtake	103
7 Overall field design and support facilities	119
8 The project development process	143
9 Decommissioning	157
10 Safety management	165
11 Environmental management	179
12 Licensing and fiscal regimes	199
13 The economics of petroleum operations and investments	217
14 Responsibilities to society and business ethics	257

Preface

This book on *Petroleum Resources with Emphasis on Offshore Fields* addresses the challenges of transforming hydrocarbons that exist in the underground, to valuable products that can be sold and delivered. It is intended for readers who have a professional or student interest in the petroleum industry, and a basic level of prior knowledge in the technical and commercial aspects of the industry. The goal of the book is to increase the reader's general understanding of key work processes in the “upstream” part of the petroleum industry, that is, the part of the industry that locates underground resources and converts them to valuable products.

The need for a book on the theme of *Petroleum Resources with Emphasis on Offshore Fields* arises from several conditions:

- Much work in the petroleum industry is carried out in *interdisciplinary project teams* and work processes. Involved personnel need to understand the wider context of petroleum resource development, and to share a terminology related to this.
- Decision makers need to *evaluate all aspects of the value chain* to identify optimal field development solutions.
- There is a need to recruit *new graduates* to the industry to work for oil companies and the engineering and service industry. Recruits to the industry will benefit from a general introduction to key topics related to developments of petroleum resources.
- Courses in the field of petroleum developments need to be supported by a *reference book* that can supplement presentations and serve as a learning resource for students.
- Scientists in different areas of the offshore oil and gas industry lack in many aspects the full understanding of the complexity of the industry. There is thus the need for a book that will serve as a reference book for scientists who need to increase their knowledge about other aspects than their own area of expertise in order to carry out their research or become involved in interdisciplinary research projects.

This book was initially written as reference book for training programs, notably Petrad's 8-week course on “Petroleum Developments and Operations,” and the course on “Offshore Field Development” at the University of Stavanger. These courses are attended by students from many parts of the world, including areas that are in early stages of hydrocarbon developments as well as Norway with its established offshore petroleum provinces. Although intended to be useful in a wide range of contexts world wide, it has particular emphasis on offshore developments, and is based to a large extent on insights from Norwegian offshore projects.

The scope of the book has thereafter been extended to incorporate the needs of scientists that need an interdisciplinary view of the oil and gas industry to carry out their research ambitions.

The cooperation with a number of former colleagues in Statoil and with the management of the Petrad Foundation is very much appreciated. Particular assistance has been received from Bernt Thorbjørnsen, Oddbjørn Tolo, and Jonas Odland from Statoil and Ellinor Melbye from Petrad. Alfred Kjemperud and Bjørn-Erik Leerberg have provided valuable background on licensing systems. Kjell Traa has contributed as co-author of parts of Chapters 4–6 and 10.

Acknowledgments are also extended to John W.A. Coker, who first led a course on “Management of Petroleum Development and Operations” for Petrad.

A group of enthusiastic students assisted to prepare the first draft manuscript of the book: Anna Elofsson, Anja Holmefjord, Frida Mathayo, Bård Solvang, and Mathilde Wilhelmsen. Their efforts are greatly appreciated. Thanks are also extended to Akaradech Apornsuvan who has assisted to prepare figures for the book.

It is the hope that the book will be of value to the readers and that it will serve its purpose as reference book for those, including the researchers, needing an interdisciplinary reader on the subjects involved in the development of petroleum resources.

The Petroleum Safety Authority (PSA) of Norway (www.ptil.no), located in Stavanger, has supported the publication of the book, while Aker Exploration, Norway, and Aker Geo, Norway, have contributed with funds to enable printing of the book. Their support is greatly appreciated.

Ove T. Gudmestad, Anatoly B. Zolotukhin, and Erik T. Jarlsby

University of Stavanger, Stavanger and
Gubkin State University of Oil and Gas, Moscow, 2010