

# **PETROLEUM GEOLOGY OF THE PERSIAN GULF**

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## PREFACE

The intention of this book is to provide a detailed synthesis of the available information published on the petroleum geology of the Persian Gulf. Despite the intensive petroleum exploration which has taken place in the Persian Gulf over the past seventy years, relatively little has been published in the petroleum geology literature. One of the main reasons for this is that many of the studies are undertaken either for or by oil companies, who, for competitive reasons, impose restrictions on publication to maintain confidentiality. This information will aid in estimating oil and gas reserves as well as improving field development technology.

Much work remains to be done regarding the geology of the Persian Gulf. The need for a book on the geology of the Persian Gulf is therefore clear, and it is hoped that it will continue to provide a useful reference manual and resource of ideas for students as well as professionals.

As it is almost always the case with a book of such nature, it is impossible to provide a comprehensive and thorough coverage of geologic and sedimentologic studies in the Persian Gulf. Although this book is not intended to give an impression of the breadth of studies being carried out and the variety of approaches implemented, it should hopefully begin to rectify this, and to provide information on some of the key points.

Progress in the oil and gas producing industry is related closely to the improvement in exploration techniques and increase in discovery rates. Indeed, exploration and production of hydrocarbon resources must be based on reliable scientific information. Considerable amount of geological, geophysical, petrophysical, geochemical, and engineering information has been gathered over more than decades of oil and natural gas exploration and production in the Persian Gulf. The geological history of this economically important region has become increasingly better-investigated in recent years and this trend will undoubtedly continue.

This book takes the reader through the most fundamental description of geological history in the Persian Gulf region. Geoscientific knowledge concerning the Persian Gulf region has been widely scattered in many published works and attempt has been made to survey these materials. The present book also has an important academic purpose. The compilation and editing of this book required the assistance and cooperation of many people. A number of reviewers also dedicated their time to significantly improve the technical merit of each contribution.

It is hoped that the present contribution to the geology of the Persian Gulf will be of interest to stratigraphers and sedimentologists as a general background reference book, to those involved in geophysical exploration, and to environmental geoscientists who are interested in protecting the natural environment of the Persian Gulf as one of the most valuable and magnificent parts of the world.

This book on the Petroleum Geology of the Persian Gulf contains eleven chapters. It provides a broad, but not superficial, introduction to various aspects of the geology of the Persian Gulf.

**Chapter one** provides a general introduction including a brief historical background on the Persian Gulf and its magnificent history, and also some remarks about the history of oil exploration.

**Chapter two** is concerned with the physical oceanography of the Persian Gulf including the description of water circulation and hydrological aspects, water chemistry and movements of water. In general the Persian Gulf has been the subject of extraordinary neglect by modern oceanographers, remarkably so in view of the economic and political importance of the area, and the vast amount of marine trade carried on, principally in tanker traffic. This chapter emphasizes the need for better oceanographic knowledge of the Persian Gulf.

**Chapter three** mainly addresses the stratigraphy of the rock successions in the Persian Gulf region with description of the Precambrian to Recent rocks. The paleogeography, paleontology and facies of the Persian Gulf are also reviewed.

Many stratigraphic columns have been studied by various workers from both subcrops (well logs) and outcrops (measured) sections in various parts of the Zagros Belt and the northern Persian Gulf. Based on this database and available published stratigraphic, sedimentological, and petrographic information, a description for each stratigraphic unit has been presented in this chapter. Such work forms the basis for a synthesis of the uppermost Neoproterozoic through Phanerozoic successions, and provides a framework upon which a scheme for Persian Gulf region geologic evolution can be established.

**Chapter four** is on the source rocks for hydrocarbons. The petroleum charge system requires source rocks, which must be capable of generating and expelling petroleum, and have a migration pathway into the reservoir unit. Possible source rocks within the Persian Gulf and surrounding region and their potential have been presented in this chapter. In different parts of the Persian Gulf, sediments of quite different types and age have been suggested as the source rocks, and evidently quite different organic materials are candidates as source. The quantities of organic sediments have been regarded as inadequate for the production of the oil and gas and would probably be seen to be much more inadequate still, if one allowed for the large natural seepage rate of the region observed since ancient times.

**Chapter five** is confined to a selection of representative, relatively well-documented accounts of carbonate and clastic reservoirs in the Persian Gulf and surrounding region. One of the objectives of this chapter is to focus on the geology of a select number of reservoirs and to present geologic case studies. The cases also demonstrate the depositional settings and facies, diagenesis and the resulting petrophysical modification of these facies, and the reservoir properties that resulted from all these interrelated factors.

The small number of reservoirs cited in this chapter provided a reasonable representation of known reservoirs in the Persian Gulf, since carbonates are the principal reservoirs in majority of the oil fields. The chapter also focuses on the lithology and depositional settings of the producing formations of the Persian Gulf, and describes the habitat of the hydrocarbons (sources, reservoirs, and seals) for the region. Non-producing formations are also described to give the reader a general sense of local stratigraphy.

Included in this book (i.e., **Chapter six**), is a chapter on caprocks. Petroleum generation remains the rate-limiting factor in the formation of a petroleum system but competent caprocks are vital for commercial accumulations of petroleum in the sedimentary basin. The characters of efficient seals, including the regionally extensive evaporites and shales, especially in Upper Jurassic, Cretaceous and most importantly Miocene have been described.

**Chapter seven** is on the structural history of the Persian Gulf. Many authors have noted that the occurrence of petroleum seems to be more closely related to large-scale tectonic features of the crust than the magnitude of organic sedimentary deposits. Within the petroliferous province of the Persian Gulf, it is indeed common to find many different stratigraphic levels that are productive. The tectonic framework and evolution of the Persian Gulf is the focus of this section, with a review of the structural significance of the Zagros zone. The present tectonic picture of the Persian Gulf region is described in this chapter is written by Dr. Shahram Sherkati of the National Iranian Oil Company.

Salt Diapirism is dealt with in **chapter eight**. The subject of how structures are evolved is very important to understand because they are associated with major hydrocarbon reserves in the Persian Gulf. In this regard salt diapirism plays a very important role. Dr. Abbas Bahroudi is the main author of this part of the book and he has extensive experience in salt tectonic of the Persian Gulf region.

**Chapter nine** is concerned with some of the oil fields located in mostly Iranian waters of the Persian Gulf. This includes development, exploration and production history of the field and a summary of stratigraphy and reservoir characteristics. In the Persian Gulf, similar to the onshore region surrounding it, a close association of suitable source rocks and high quality reservoirs appears to be the most significant factor in the development of the great productivity of the Persian Gulf region. The main idea for organizing this chapter comes from Mr. Homayoun Motiei.

**Chapter ten** is a review of the geophysical activities during the past few decades and the initial draft was contributed by Mr. C. Amir Behboodi and Mr. A. Memarzia and revised by Dr. F. Ghazban. The chapter also provides some of the results of 3D seismic interpretation performed by geophysical consultants on some of the oil fields in the Persian Gulf.

**Chapter eleven** is on the environmental geology of the Persian Gulf. This chapter focuses on, the quaternary geology, environmental aspects, oil and industrial pollutions, and some climatic aspects of the Persian Gulf region.

I am deeply appreciative of the help given by others to make this book a reality. Special thanks to the University of Tehran for publishing the second edition of this book. I am very grateful to Homayoun Motiei who provided some of the background materials used in this book. Mr. Hassan Nazari significantly improved the illustrations appeared in the book. Mr. Arta Sharifi made a respectable cover design.

Special recognition and appreciation is due to my family (Shayan, Farzan and Elham) who provided me with many years of patient, understanding and encouragement while the first edition of this book was in preparation.

For the shortcomings that remain in the book, I alone feel responsible. Preparing this book was a major task and there is a lot of material used, probably too much to be error-free. I welcome all comments, pro and con, as well as suggested revisions. I hope that readers will actually enjoy reading most of this book.

This book is dedicated to all the geoscientists who contributed greatly to the knowledge and our understanding of the geology of southern parts of Iran and the Persian Gulf.

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July, 2008  
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## **ACKNOWLEDGEMENT**

The National Iranian Oil Company sponsored the publication of this book. The University of Tehran vice president of research and academic and the chief author of this book Dr. Fereydoun Ghazban would like to thank National Iranian Oil Company for their financial support.

Many people have helped considerably in putting together this book. Homayoun Motiei formerly of the Research and Development Division of the NIOC provided considerable feedback, significant input and encouragement and much needed council during the editing and preparation process. Eng. Abdolhamid Memarzia, the former exploration manager of the Iranian continental offshore company, was a prime source of encouragement throughout the publication of this book and acted as a driving force from the initiation stages of this project. Professor M. A., Ala of the Imperial College in London also provided several key references and his help is greatly appreciated.

Mrs. Arengo of the University of Zurich sincerely provided assistance with locating some of the key references in the library of the Swiss Technical University, geology department. Staff of the library of the exploration division of the NIOC in Tehran was also of considerable help.

The quality of the book was significantly improved by the valuable insights provided by comments from the technical and advisory board and the reviewers. The main text benefited greatly from critical and constructive reviews and suggestions by Homayoun Motiei, Mohammad Reza Kamali, Mahmood Bargiran, Elham Hajikazemi and Reza Nouri. Mrs. S. Arya of the NIOC Research and Development department also provided much needed encouragement and financial assistance throughout the work. The author also would like to thank Dr. Ali Pourmand (Tulane University) for constructive editing of the manuscript.



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