石油工业出版社

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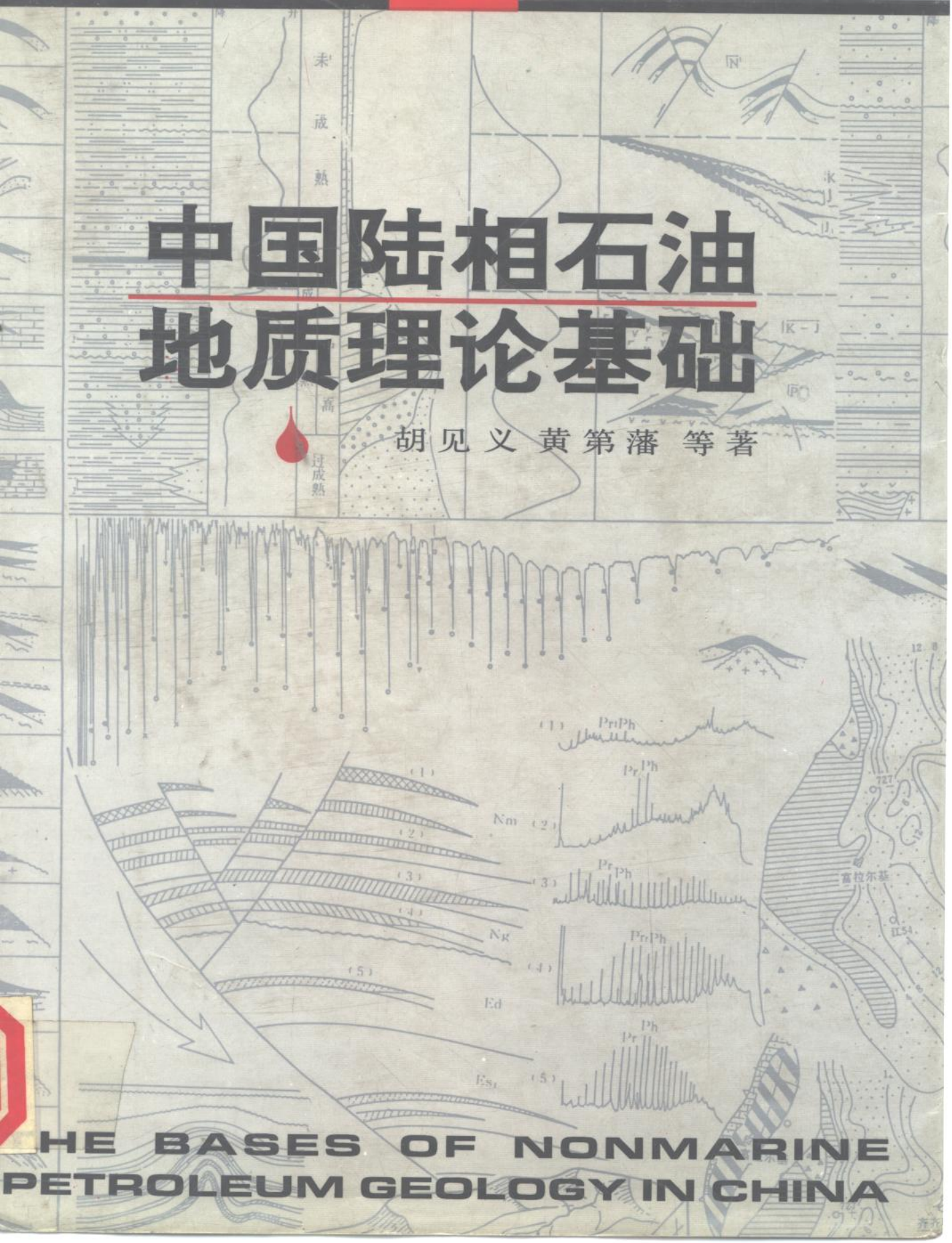

THE BASES OF NONMARINE PETROLEUM GEOLOGY IN CHINA

中国陆相石油地质理论基础

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内 容 提 要

全书共分五章，首次系统概括论述了中国陆相石油地质理论，介绍了陆相石油地质的形成和发展过程，陆相与海相地质环境对油气藏形成的作用和异同点，陆相油气藏形成的基本规律等。分别就陆相盆地的大地构造背景、石油生成、陆相沉积与储集层的形成、油气藏类型及其分布特点等进行了系统的阐述。适合石油地质勘探专业的科研、技术人员及大专院校师生阅读。

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序

20世纪是石油的世纪，不论是经济、文化、战争、粮食无不与石油有关。石油工业的科学核心之一是石油地质学。在海相地质环境中可生成大量油气并形成矿藏的认识被确认后，近几十年来，在非海相地质环境中各种类型盆地作为重要的油气远景区逐渐被人们所公识，特别是在中国取得了重大进展。在20～30年代中国西部已证实一些中小型陆相油田（沼泽—湖相），而50～60年代则在中国东部连续发现与证实了一系列湖相大型含油气盆地，稍后在世界其他国家也陆续发现一些非海相含油气盆地。非海相（或陆相）石油地质学的发展不仅有理论上的重要意义，同时推动和开拓更多的油气藏形成的新领域、新层系和新的含油气盆地。中国大陆在中新生代各时代发育与遍布不同规模的数百个非海相盆地。经过地学工作者的共同努力，陆相石油地质取得了发展。《中国陆相石油地质理论基础》一书应用现有的地质、地球化学和地球物理资料，对中国各陆相盆地作了分析与研究，总结了中国陆相含油气盆地的地质条件、油气藏形成与分布，同时阐述了陆相与海相地质环境在油气生成、运移、聚集、保存与油气藏形成分布等方面的相同与不同之处，对促进与不断开拓勘探油气藏新领域是很有益处的，对丰富和发展石油地质学也很有益处。

我国油气勘探数十年来取得了很大发展，已证实我国是含油气丰富的国家，但地质条件很复杂，需要不断发展石油地质学理论。《中国陆相石油地质理论基础》一书的出版，不仅从一个侧面阐述了中国的石油地质，也为今后更进一步发展石油地质学起了铺路石的作用。

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前　言

石油地质学作为地质学分支学科，其发展约有150年的历史。随着对油气需求的扩大，近50年来石油地质学已经成为一门成熟的、具有现代科学理论基础的应用学科。石油地质学理论的发展和奠定，是与油气藏形成于海相沉积环境这一重要论点密切相联的。在油气生成、运移和聚集的诸多条件中，稳定的海相沉积环境是理想的、重要的，这对全世界的油气田的形成、分布研究和勘探实践具有重大意义。

20世纪中叶，不少石油地质学家注意到了陆相沉积含有油气的事实，但是，在不稳定的陆相沉积环境中，是否具备有机质堆集、保存和向烃类转化、运移，并形成油气藏的条件，特别是能否形成较大规模的油气聚集和大油气田，是石油地质学家没有解决的问题。中国地质学家在进行科研和勘探的过程中，最先注意并着手研究陆相油气存在的可能性。继1907年发现了延长油田后，30～40年代，在陆相沉积中又发现老君庙、石油沟等一系列中、小型油气田。随着勘探和研究的深入，50年代末发现了举世瞩目的特大型油田——大庆油田。由于该油田是在陆相白垩系中，且油源也来自白垩系，所以这在石油地质学上是一次重大的突破和发展。之后，中国和世界上众多陆相含油气盆地的相继发现，以及相应科学研究的深入，陆相油气藏的形成理论日渐成熟与完善，不断开拓出新的油气田分布领域，丰富与发展了石油地质学。

为了深入研究和发展陆相石油地质理论，推动陆相石油勘探，不仅需要承认和肯定陆相沉积环境可以形成大油气藏，更重要的是阐明它的理论和意义。为此，本书概括论述了陆相石油地质理论的形成和发展过程，陆相与海相沉积环境对油气藏形成的作用和异同点，陆相油气藏形成的基本规律等。本书分别就中国陆相盆地的大地构造背景、石油生成、陆相沉积与储集层的形成、油气藏类型及其分布特点等，进行了阐述。笔者的愿望是总结与介绍陆相石油地质理论，借以推动它的发展，并不断丰富石油地质学。本书中许多基本论点还有待完善，尚需更多、更深入地进行科学研究工作，以提高和发展陆相石油地质理论，这也是中国以及世界不断开拓新的陆相含油气盆地所需要的。陆相石油地质理论和陆相含油气盆地的油气勘探一样有着广阔的发展远景。

全书由胡见义、黄第藩等著，前言和第一章总论由胡见义执笔，第二章中国陆相含油气盆地的大地构造背景和盆地类型由甘克文执笔，第三章陆相盆地的沉积和储集层由薛叔浩、应凤祥执笔，第四章陆相油气生成的理论基础由黄第藩、李晋超、张大江执笔，第五章中新生代含油气盆地油气藏与油气分布由徐树宝、胡见义执笔。序、前言和目录由周家尧翻译成英文。

在本书写作过程中得到北京石油勘探开发科学研究院有关研究所和科技人员的有力支持，也得到有关油田和研究院、所的大力协助，在此一并感谢。由于作者水平有限，本书难免有许多不当之处，敬请广大读者指正。

PREFACE

The 20th century is an era of petroleum energy, the development of almost everything such as industry, communication, culture, warfare, and food, are all related to petroleum, One of the scientific nuclei of petroleum industry is petroleum geology. Since last several decades, after people affirmed that oil and gas deposits are generated from marine sediments, the prospects of oil and gas in various nonmarine basins are recognized gradully, especially in those of China. In 20th and 30th of the century, some oil fields from continental sequence (swamp–lacustrine sediments) with small to middle scale had been proved in western China; from the late 50s to 60s, a series of giant oil fields had been found and comfirmed successively in lacustrine basins of eastern China. Then some nonmarine oil and gas fields had been discovered in some other countries worldwide. The development of nonmarine petroleum geology is not only of theoretic significance, but also can promote the petroleum exploration for new sedimentary basins, new areas, and new sequences.

There are hundreds of Meso–Cenozoic nonmarine basins with various extent in China continent. Through the efforts and exploration practice of geologic workers, the nonmarine petroleum geology has been developed a lot. Using geological. geochemical, and geophysical infromation available, the authors discribed the nonmarine basins in China, summarized the geological conditions of the fromation and distribution of petroleum accumulations of nonmarine oil and gas, and expounded the similarities and dissimilarities between nonmarine and marine geological settings. The book is beneficial to openning up new frontiers for oil and gas exploration, and to enriching petroleum geology.

China has been proved to be rich in oil and gas through decades of oil and gas exploration practice; but the geological conditions of those basins are so complicated that extensive researches are still needed. "The Bases of Nonmarine Petroleum Geology in China" not only makes an exposition of petroleum geology in China from one aspect, but serves as a corner stone for the further development of petroleum geology afterwards.

Wong Wenbo

FOREWORD

Petroleum geology, a branch subject of modern geology, has been developed for about 150 years. It has become a theoretically matured applied science with the increasing demands for oil and gas resources in recent 50 years. The development of petroleum geology and its theory establishment are closely related to an important argument of oil and gas generated in marine environments. Among those conditions of oil and gas generation, migration, and entrapment, a stable marine environment is an ideal and important condition, which is of great significance for the study of petroleum occurrence, and exploration practice worldwide.

In the middle of 20th century, quite a few petroleum geologists considered the fact that some oil and gas fields discovered in continental sequences, but the question whether there are favorable conditions for organic matter accumulation, preservation, transforming to hydrocarbon, as well as for oil and gas migration to formation a great number of petroleum accumulations, especially. those giant oil fields in unstable nonmarine environments, still unsolved. Chinese geologists are the first to have noticed oil and gas occurrence in nonmarine sediments through their research and exploration experiences.

Since the discovery of Yanchang oil field in 1907, a series of oil fields with small to middle scale such as Laojunmiao and Shiyougou have been found during 30s and 40s of the century. Daqing oil field, a supergiant oil field which attracts worldwide attention, was discovered in 1958 through intensive research and exploration practice. The discovery marks a milestone of petroleum geology for the reservoirs and source rocks are all in nonmarine Cretaceous formations. Afterwards many continental oil and gas fields have been found successively in China and the world. Meanwhile the scientific research of the nonmarine sedimentary basins has been deepened, the theory of nonmarine petroleum geology has become more matured and perfect, which will encourage to open up new frontier for oil and gas exploration and to advance petroleum geology.

In order to research the theory of nonmarine petroleum geology deeply and promote nonmarine petroleum exploration, we need not only to define that petroleum accumulations can be formed in nonmarine geological settings, but also to expound the significance of nonmarine petroleum geology theory more importantly. Thus, "The Bases of Nonmarine Petroleum Geology in China" has briefly reviewed the history of the generation and development in nonmarine petroleum geology, discussed the similarities and dissimilarities in the formation of petroleum accumulations between marine and nonmarine geological settings, and elaborated the basic theses of nonmarine petroleum geology. The book have made a systematic exposition of the tectonic settings, oil and gas generation, sedimentation and reservoir rocks, types and distribution of petroleum accumulations of nonmarine sedimentary basins. As a summary of and an introduction to nonmarine petroleum geology, the authors wish it

can promote the development of nonmarine petroleum geology and enrich it as a whole. But even at present, some basic theses of nonmarine petroleum geology are not yet perfect, so more detail scientific researches are needed to develop the theory of nonmarine petroleum geology, which are also needed in China as well as in the world to open up new areas of nonmarine sedimentary basins. We believe that nonmarine petroleum geology and petroleum exploration for nonmarine oil and gas bearing basins have great expectation.

Mr Hu Jianyi and Huang Difan are the editors–in–chief of the book. The Foreword and Chapter 1 are written by Hu Jianyi, Chapter 2 by Gan Kewen, Chapter 3 by Xue Shuhao the Ying Fengxiang, Chapter 4 by Huang Difan, Li Jinchao and Zhang Dajiang, Chapter 5 by Xue Shubao and Hu Jianyi.

In preparing the book, we accepted effective support from relavent research departments and individual researchers in RIPED (Research Institute of Petroleum Exploration and Development), obtained a great helps from related oil fields and research institutes. To each of these we extend our gratitude.

目　录

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第一章 总 论

第一节 陆相石油形成问题的提出

人类发现并利用天然气和石油可以追溯到几千年以前（甚至公元前600年），但是应用近代科学技术发展石油天然气的能源工业只有100多年的历史。19世纪中叶，苏、美学者分别对苏联高加索地区的油田和美国阿巴拉契亚山前坳陷的油田进行研究和描述，在这一时期前后，许多学者，特别是地质家、化学家利用近代科学对石油、天然气的成因和分布开始进行广泛的探讨。经过一百多年的理论探讨和石油、天然气勘探的实践，逐渐形成和完善了系统的油气生成、聚集和油气藏形成、分布的理论。这一理论的基础和结论都认为，石油的生成和油气藏的形成都是在特定的大地构造单元内的海相环境中进行和生成的。这一理论的完善过程是与石油的勘探实践紧密联系的。

在1863年加拿大著名石油地质家Hunt，T.S.详细阐明了石油的原始物质是低等海洋生物，他说："在北美古生代岩石中，曾产生沥青有机物质，它们是由海生植物衍生来的，或者是由海洋动物的残余部分衍生的。"

苏联最早开始清楚的论述油气起源的是苏联地球化学之父Вернадский，В.Э.(Vernadskii，V.I.)，他于1934年在其名著《地球化学概论》中说："石油生成的一般特征是清楚的，我们应该认为，石油是沉积矿物，与有机质有成因上的联系。"他又说："天然气成因与油田有关，它们是石油的气相，另一部分天然气与沉积岩中分散有机质有关，它们的成因可以用海洋生物—海洋软泥—沉积岩层—天然气的模式表达。"

在1943年美国地质家Pratt，W.E.对烃类的存在作过重要的论述："石油是地球基本作用的一个必然结果，在地球历史中，这种作用很典型的，在连续的循环中不断重复，我相信地球上的石油远远比通常认识到的更丰富，并且分布的更广泛。石油是未变质的近海成因的海相岩层中的组成部分，这种特征的岩石地层占地球大陆面积的40%以上。"

在20世纪中叶，石油勘探已在全球范围内开展，许多大油气区相继发现和深入勘探开发。与此同时，地质学、地球化学、地球物理学科的理论与技术迅速发展，使油气的形成和聚集理论建立在更加科学的基础之上。1956年苏联Бродˊ，И.О.和Еременко，Н.А.在《石油天然气地质基础》著作中，阐明"水下环境是有机物堆集和向石油转化的最重要和最有利条件"，"区域性含油层系非常清楚地是水下形成的，这些层系绝大部分为咸水海相成因"。50年代美国著名石油地质家Levorsen，A.I.在《石油地质学》一书中也得出结论："几乎所有石油产生于沉积物中，这些沉积物基本上是海相成因，因此，它所贮存的石油也很可能是海相的或者与海相条件有关的"。因此，在近100年的时间内，石油的海相成因是不容置疑的。

随着石油勘探的广泛展开，50年代以来，在中国、蒙古、巴西、巴基斯坦、哥伦比亚、澳大利亚等国的一些盆地，相继在陆相地层中发现石油、天然气或油气显示，这无疑对纯海相环境成油理论给予一定的冲击，促使地质家从更广泛的角度考虑石油的生成和聚集。如Бродˊ和Еременко在《石油天然气地质基础》（1957年再版）中指出的"在蒙古和中国的一些含油气层系形成于淡水陆相盆地"的事实。由于当时海相成油理论的绝对优势，对陆