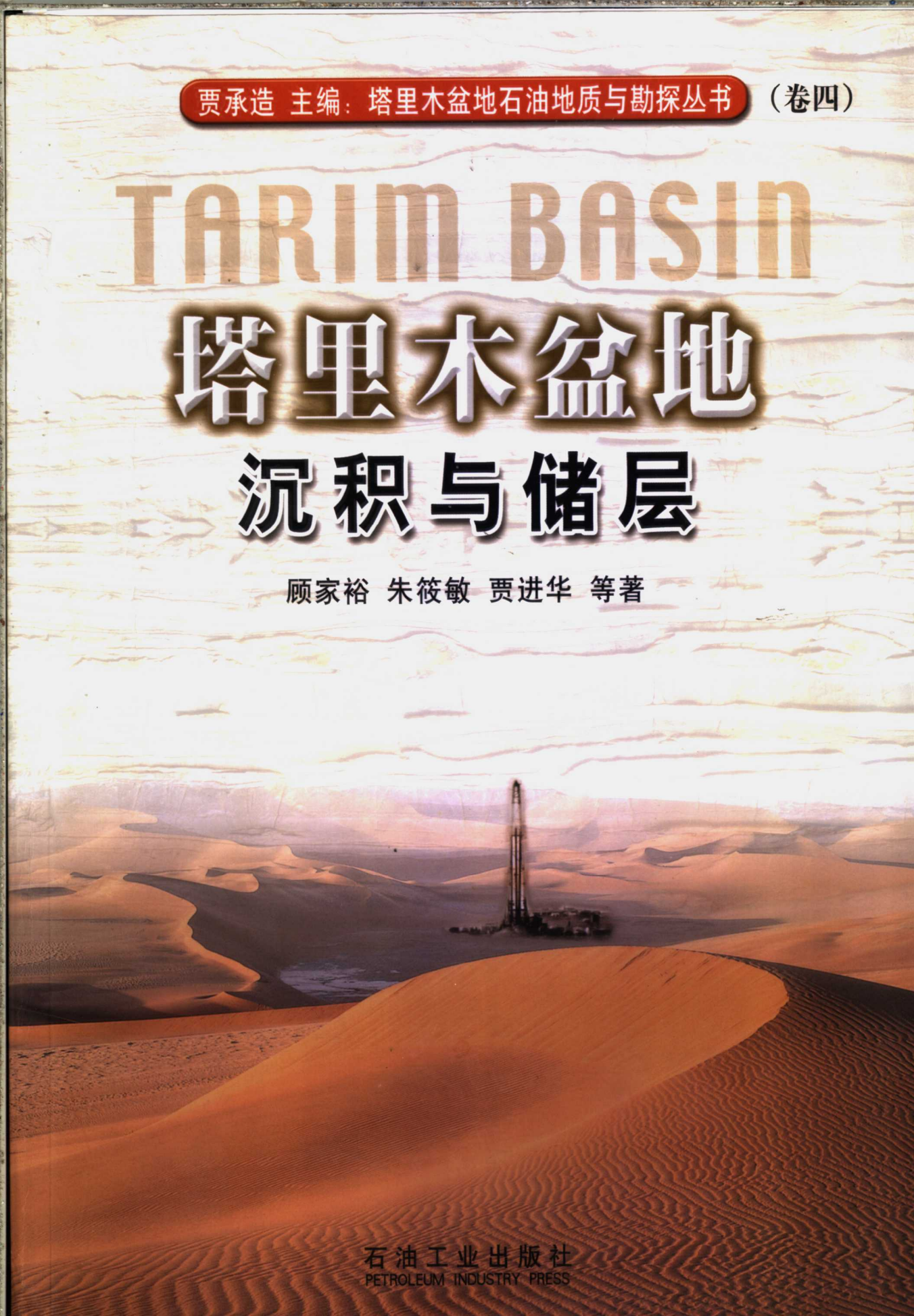
贾承造 主编：塔里木盆地石油地质与勘探丛书（卷四）

TARIM BASIN

塔里木盆地

沉积与储层

顾家裕 朱筱敏 贾进华 等著



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顾家裕　朱筱敏　贾进华　等著

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内 容 提 要

本书在大量地震、地质、测井和钻井资料结合的基础上，以层序地层学和沉积学为主线，对塔里木盆地台盆区古生界、新生界和库车坳陷的中、新生界的沉积特征、沉积相分布和储层特征和分布预测作了新的研究和总结，特别是对台盆区碳酸盐岩各有关成岩作用、深埋岩溶及各层系碎屑岩的优质储层发育机理作了详尽和深入的研究和探讨。

本书可供从事石油地质、沉积学等专业的科研人员、现场工作者及大专院校师生参考。

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《塔里木盆地石油地质与勘探丛书》

编　委　会

序

以“九五”期间勘探与研究成果为内容的《塔里木盆地石油地质与勘探丛书》一套十二卷即将面世，这是“九五”期间奋战在塔里木盆地这块热土上的全体石油地质工作者集体劳动的结晶，也是石油工业出版社同志们辛勤劳动的产物。它是塔里木盆地油气勘探史上重要的一环。丛书的出版，必将引起国内外石油界的广泛瞩目和浓厚的兴趣，我对丛书的出版表示热烈祝贺。

塔里木盆地的油气勘探从20世纪50年代算起已经有50多年了，其间因为种种原因，经历了“几上几下”的曲折历程，也积累了丰富的资料和经验教训。1989年4月经国务院批准由中国石油天然气总公司组织了塔里木盆地石油会战，从而为在塔里木盆地大规模全面展开油气勘探迈出了扎实的历史性的步伐。与此同时国家也组织了相应的以塔里木盆地油气勘探为内容的“八五”和“九五”的重点攻关项目。

《塔里木盆地石油地质与勘探丛书》的内容，正是在广大石油工作者近40年野外和盆地周边地质调查和钻探、石油地球物理勘探局挺进大漠后连续苦干近20年所取得的丰硕资料，在“七五”和“八五”国家重点攻关研究工作的基础上，通过5年或更长时间的实践和研究所取得的成果，在此期间，对重点地区和重点层系进行了艰苦有效的研究和实践，应该说取得了令人满意的勘探成果，开创和深化了新的理论和认识，特别在复杂断裂构造带和碳酸盐岩中进行油气勘探，积累和丰富了大量储层描述和评价、地震采集和处理、测井、完井、试油等一系列理论、技术和工作方法。

“九五”期间，共发现或探明了13个大、中型油气田，27个工业性含油气构造。发现和探明了大型整装的克拉2大气田，探明天然气地质储量$2840\times10^8m^3$，发现了库车坳陷的富天然气聚集带，为“西气东输”奠定了资源基础；继续探明了塔河一轮南大油田。近5年来新增油气地质储量5.905×10^8t（当量），其中石油地质储量1.908×10^8t，天然气地质储量为$3997\times10^8m^3$，2000年生产原油440×10^4t。

通过“九五”期间勘探和研究，对库车前陆盆地石油地质的认识取得了重大进展，初步形成了库车大气区的石油地质理论基础；在古生代海相碳酸盐岩油气成藏规律研究、克拉通主力烃源岩评价、海相碳酸盐岩和碎屑岩储层发育机制及成藏期与成藏模式研究等方面，取得了新进展，丰富了海相石油地质理论，深化了对古老克拉通盆地海相油气分布规律的认识；对塔里木盆地石油地质的深入研究，明确了塔里木中、新生代盆地大地构造背景及包括塔里木盆地在内的特提斯北缘盆地群的油气地质特征；进一步总结和完善了塔里木盆地油气的富集成藏规律，评价优选出了一大批有利勘探区带和目标，明确了塔里木盆地油气勘探的战略发展方向，并形成了一系列油气勘探的技术和方法。

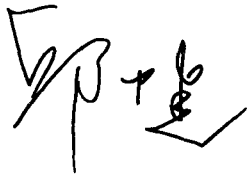
特别是库车前陆盆地创造性地运用断层相关褶皱理论，在库车前陆盆地褶皱—逆冲构造带建立了10种构造模型，并用于地震剖面精细构造解释和制图；应用煤成烃理论，深入分析和系统评价了库车前陆盆地三叠—侏罗系煤系地层烃源岩。提出库车前陆盆地发育分布广、厚度大、有机质丰度高、有机质类型以腐殖型为主、成熟度高的煤系地层烃源岩等，初步认识了库车大气区的石油地质特征。

针对山地地震勘探、高陡构造钻井、超高压气藏测试和评价、碳酸盐岩孔、洞、缝型储层的识别和预测及超深、低幅度薄层砂岩油藏勘探等一系列难题，加大了勘探技术攻关的力度，初步形成了五套油气勘探评价技术系列，基本满足了当前塔里木盆地油气勘探的需要。

这套丛书系统总结了“九五”及前人对塔里木盆地的勘探和研究工作，特点是总结了5年的勘探实践和认识。其中既有勘探的认识和基础研究成果，也有油气富集规律的总结和新技术、新方法的应用，内容十分丰富，对今后塔里木盆地乃至其它相似盆地的油气勘探有一定的借鉴意义。但我们认为，这些成果并不都是十分成熟、十全十美的，正相反，毕竟塔里木盆地情况十分复杂，勘探程度还比较低，许多难题还尚未解决，勘探的道路还很漫长，我们的认识虽有大的进步，但还有很多不清楚和不明白的环节和规律。可贵的是，塔里木盆地的石油地质工作者勇于实践，勇于探索，锲而不舍，不断进取，及时总结经验和教训，敢于把这些成果亮出来，接受实践的检验，在实践中深化认识。我相信，这套丛书的出版，定会丰富中国石油地质学的理论与实践，并对今后的勘探工作起到重要的指导作用。

随着塔里木盆地油气勘探不断深入并取得更大进展，人们的认识将会更加接近客观实际和事物的本来面目，通过继续不断地努力和探索，定会实现油气勘探的飞跃。到那时，中国石油工业的希望——塔里木盆地，将出现更多的克拉2和塔河一轮南型的大型油气田，进入新的油气储量增长的高峰期，塔里木盆地真正成为中国石油工业战略接替基地，我对此充满信心。

最后，我衷心希望丛书的出版能够起到“抛砖引玉”的作用，能够在一定程度上满足全国石油地质界关心和支持塔里木盆地找油事业的专家同仁的需要，并引起更多人的兴趣，从而参加到塔里木盆地油气勘探的接力赛的行列中来，共同投身到富有诱惑、充满挑战而又奥秘神奇的塔里木盆地这块热土中来。



2003年6月

Preface

The 12-volume collection of *Petroleum Geology and Exploration of Tarim Basin*, the content of which is the exploration and research achievements during the "Ninth Five-Year Plan" period, will be published. This collection is the crystallization of all petroleum geologists ever fought in hot land of Tarim Basin during the "Ninth Five-Year Plan" period and the product of arduous work of comrades of Petroleum Industry Press. It is one important page of the hydrocarbon exploration history of Tarim Basin. After being published, this collection will undoubtedly be widely cared by domestic and foreign petroleum circles and bring them great interest. I hereby express my congratulation to the publishing of this collection.

Hydrocarbon exploration work in Tarim Basin started in 1950s and till now it has an over-50-year's history. In this course, the exploration personnel had suffered with many frustrations for various reasons but they also obtained rich materials, experiences and lessons. China National Petroleum Corporation, after approved by the State Council, organized a mass petroleum exploration campaign in April 1989, which was a firm and historic step for the large-scale overall hydrocarbon exploration in Tarim Basin. Meanwhile, the state also organized some "Eighth Five-year Plan" and "Ninth Five-Year Plan" brainstorm projects focusing on hydrocarbon exploration of Tarim Basin.

The content of the collection of *Petroleum Geology and Exploration of Tarim Basin* is full of the plentiful and substantial materials that have been obtained by a lot of petroleum workers through field geologic survey and drilling work around the basin in nearly 40 years and through continuous hard work for nearly 20 years after the Bureau of Geophysical Prospecting. This collection also contains the achievements that have been obtained through the practice and research for five years or more time based on the national key brainstorm research work during the "Seventh Five-year Plan" and "Eighth Five-year Plan" period; during this period, geologists had conducted hard but effective studies and practice on key regions and key series of strata. This course does obtain satisfying exploration achievements and initiate and deepen new theories and understandings. Especially, the hydrocarbon exploration work in complicated fracture zones and carbonate helps geologists in accumulating and enriching a series of theories, technologies and work methods such as large reservoir description and evaluation, seismic acquisition and processing, well logging, well completion and oil test and so forth.

During the "Ninth Five-Year Plan" period, 13 large/middle oilfields / gasfields and 27 gas-/oil-bearing structures available for industrial application in total have been discovered or proven. The large self-contained Kela-2 Large Gasfield was discovered and proven during this period, the proven geological reserves of natural gases of which are $2{,}840\times10^{8}m^{3}$, while the rich natural gas accumulation zone was discovered in Kuche Depression, which establishing the resource foundation for the "West-East Pipeline Project". Later, Tahe-Lunnan Large Oilfield was ascertained. In recent five years, $5.905\times10^{8}t$ (equivalent weight) of geological reserves of oil and gas have been

ascertained, including $1.908x10^8$t of geological reserves of petroleum, $3,997x10^8m^3$ of geological reserves of natural gas. In 2000, the production of crude oil reached $440x10^4$t.

Through the exploration and research during the "Ninth Five-Year Plan" period, the understanding to petroleum geology of Kuche Foreland Basin has had an important breakthrough, and the theoretical foundation for petroleum geology has been preliminarily established for the large natural gas area in Kuche. In such aspects of research on Paleozoic marine carbonate hydrocarbon reservoir formation law, evaluation on major hydrocarbon source rock in Craton, research on development mechanism of marine carbonate and clastic reservoir, reservoir formation period and reservoir formation model and so on, some new progresses have been obtained, which has enriched the theory relating to marine petroleum geology, deepened the understanding on marine hydrocarbon distribution law of ancient cratonic basin. The deep research on petroleum geology of Tarim Basin ascertains the tectonic background of the Cenozoic basin of Tarim and the geological characteristics of hydrocarbon in basin groups in north edge of Tethys including Tarim Basin; it further concludes and perfects the occurrence and reservoir formation laws of hydrocarbons in Tarim Basin, evaluates and optimizes a large batch of favorable exploration areas, zones and destinations, determines the strategic development direction for hydrocarbon exploration of Tarim Basin and obtains a series of hydrocarbon exploration technologies and methods.

Especially, in Kuche foreland basin, geologists have innovatively applied the fault-related folding theory to establish 10 structure models in the fold-thrust structure zones of Kuche foreland basin and used it for interpretation and plotting of fine structures of seismic profile; the theory that states how coal is turned into hydrocarbon has been used to deeply analyze and systematically evaluate the hydrocarbon source rocks in the Triassic-Jurassic coal measure strata in Kuche foreland basin. It proposes the opinion that the coal measure strata hydrocarbon source rocks of wide distribution range, large thickness, high organic matter abundance, humus as main organic matter and high maturity are developing in Kuche foreland basin, while preliminarily understanding the petroleum geological characteristics of Kuche large gas area.

The brainstorm strength of exploration technologies is increased for a series of difficulties such as mountainous seismic exploration, drilling of high and steep structure, testing and evaluation on super-high pressure gas reservoir, recognition and prediction of carbonate hole, pore and seam-shaped reservoir, exploration of super-deep, low-amplitude thin sandstone oil reservoir, preliminarily establishing five sets of hydrocarbon exploration and evaluation technologies, which basically meet the current hydrocarbon exploration need of Tarim Basin.

This collection systematically concludes the exploration and research work that was carried during the "Ninth Five-Year Plan" period and by predecessors. Especially, it concludes the exploration practice and understandings obtained in past five years, including the understandings to existing exploration and basic research achievements and also including the conclusions of hydrocarbon occurrence law and application of new technologies and methods. Its contents are very rich and have a certain guiding significance to the future hydrocarbon exploration in Tarim Basin and other similar basin. However, we do not think that these achievements are very mature and perfect. On the

contrary, as the situations of Tarim Basin are very complicated, its exploration degree is relatively low, there are many difficulties unsolved and the exploration road is still very long, in our understandings there still are many unclear links and laws although there is a large progress. It is notable that the petroleum geologists in Tarim Basin are brave in practice and probing into new fields, they can work with perseverance for greater progress, and they are always summarizing experiences and taking lessons from practice, and they are brave to inspect their achievements in practice so as to deepen their understandings in practice. I believe that this collection will undoubtedly enrich the theories and practice of China's petroleum geology and play an important guidance role to the future exploration work.

As the hydrocarbon exploration in Tarim Basin has been continuously deepened and more progress has been obtained, our understandings will be closer to the reality and the original appearance of things. Through continuous efforts and exploration, our hydrocarbon exploration will undoubtedly have a forward leap. Till then, the hope of China's petroleum industry--Tarim Basin will produce more large oilfields and gasfields like Kela-2# and Tahe-Lunnan and get into a new peak stage of hydrocarbon reservoir, and Tarim Basin will really become the strategic base of China's petroleum industry. I am confident in this.

Finally, I sincerely hope that the publishing of this collection can play the role that offers a few commonplace remarks by way of introduction so that others may come up with valuable opinions, can in a certain degree meet the need of those experts in the national petroleum geology field who concerns with and support the petroleum exploration work in Tarim Basin, and can intrigue more people, so that there are more people to throw themselves into the hydrocarbon exploration relay race of Tarim Basin and to step into the charming and mystic Tarim Basin full of challenges.

Qiu Zhongjian

June 2003

前　言

塔里木盆地为一巨型的叠合复合型沉积盆地，由于多次构造运动，地质条件十分复杂，本书主要针对一些沉积储层方面的深层次的问题进行了研究。

本书以板块构造学和层序地层学理论为指导，运用最新的沉积储层理论和方法，通过地震、测井、地质（野外和室内）相结合，从露头至井下，从宏观至微观，在层序地层等时格架内分析了库车坳陷中、新生界沉积分布及特征，建立沉积模式，提出了库车坳陷白垩系主要为辫状三角洲沉积，并对储层的特征、分布规律和对油气的控制作用进行了详细深入的研究和探讨，对库车坳陷的油气勘探有一定的指导意义。对台盆区的古生界和中生界的储层特征、成岩规律、孔隙演化和储层分布进行预测，特别是对台盆区古生界和中生界各层系优质储层进行了成因机理的探讨，对储层的认识得到了深化，认为台盆区深埋的碎屑岩储层的物性主要取决于后期油气生成阶段所释放酸性水对原储层的改造，同时油气的成藏和破坏对储层也有重要的控制作用。对台盆区碳酸盐岩储层做了成功且有效的工作，把碳酸盐岩的岩溶作用分为同生期岩溶、风化壳岩溶和深埋岩溶三种类型，对每种岩溶的识别标志、分布、发育规律和控制因素进行了研究和探讨；对白云岩化作用的地球化学特征和白云岩储层的影响因素进行深入的分析。上述研究工作不但丰富了沉积学理论，并在生产实践中取得了良好的效果。

本书为国家攻关项目中 99－111－01－02 专题研究报告的修改稿，在原报告的基础上由顾家裕、朱筱敏、贾进华三人进行了必要的修改和编排。

参加专题攻关的成员有（包括地层专题）：顾家裕、张师本、朱筱敏、卢辉楠、黄志斌、赵澄林、钟大康、陈景山、王振宇、罗平、朱如凯、贾进华、王建国、谭秀成、耿良玉、季汉成、代宗仰、罗忠、郭庆银、王林凤、李猛、朱怀诚、杜品德、王启飞、谭泽金、赵治信、高琴琴、王智、李椿、彭金兰、王兰、詹家桢、吕雪雁、唐洪、付秀丽、张忠民、张同钢、涂强、申银民、徐迅、李宇平、杨威、邸宏莉、王鹏、赵伦、高雷、张琴、秦启荣、曾伟、夏宏泉、谢桂生、马青、胡恒、周彦、黎平、李燕、唐志敏、张宝民、吴光宏、张秀莲、韩宇春、张传禄、孙玉善、李建军、杨帆、杨文静、刘静江、边立曾、蒋凌志、马龙、张鼐、周琦、袁子龙和唐景涛。本书是参加攻关专题人员集体的成果，是全体研究人员辛勤劳动的结晶，在攻关和报告编写过程中大家充分发挥了聪明才智，在本书出版之际致以深深的谢意。

顾家裕

2003 年 5 月

Foreword

Tarim Basin is a large superposed composite sedimentary basin with the complicated geological conditions owing to structural movements for a number of times. This book makes study of some issues existing in sedimentary reservoirs.

Guided by the theories of plate tectonics and sequence stratigraphy and based on combination of seismic, logging and geological (field and indoor) data, this book uses the latest sedimentary reservoir theory and method to analyze Mesozoic and Cenozoic sedimentary distribution and characteristics in Kuqa Depression. With establishment of sedimentary model, this book describes Cretaceous in Kuqa Depression mainly as braided delta sediment. The book makes an in-depth study and analysis of the reservoir characteristics, the distribution law and the controlling effect on oil and gas. The study and analysis are of certain guiding significance to oil and gas exploration in Kuqa Depression. The book also makes predictions on Paleozoic and Mesozoic reservoir characteristics, diagenetic law, pore evolution and reservoir distribution in the platform and basin regions, especially focusing on the genetic mechanism of quality reservoirs of the Paleozoic and Mesozoic strata series in the platform and basin regions. Based on the opinions of this book, the physical properties of the deeply buried clastic reservoirs in the platform and basin regions depend on renovation of the original reservoirs by acid water released during the later oil and gas generation stage. Meanwhile, formation and destruction of oil and gas reservoirs have important controlling effect on the reservoirs. The karst effect of carbonate rock can be divided into three kinds of karst at the syngenetic stage, weathering crust karst and deeply buried karst. The identification mark, distribution, development law and controlling factors of each kind of karst come under study and discussion. The in-depth analysis is made on the geochemical characteristics of dolomite lithifaction and the influencing factors of dolomite reservoir. The above-mentioned research work has not only enriched the sedimentary theory but also achieved the satisfactory results in the production practice.

This book is the revised version of the 99-111-01-02 special research report, one of the State's key scientific research projects. Gu Jia yu, Zhu Xiaomin and Jia Jinhua have made the necessary revision and compilation on the basis of the original report.

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