中国东部深层石油地质学丛书　第二卷

东北地区深层石油地质

谯汉生　方朝亮　牛嘉玉　关德师　主编

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内 容 提 要

本卷主要论述了东北地区区域构造与晚古生代—早第三纪岩相古地理，并着重对松辽盆地深层（泉二段以下）晚侏罗—早白垩世断陷、沉积层序、烃源岩、储盖条件与油气藏形成及分布规律，进行了全面系统的论述。另外对东北地区石炭—二叠系石油地质条件进行了分析研究。

本书可供从事油气勘探工作的科研人员参考，同时也可作为有关大专院校师生的参考用书。

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引　言

20世纪90年代以来，随着中国东部老油区勘探程度的提高，发现中小型油气田的概率逐渐上升，储量增长趋缓。为了贯彻“稳定东部，发展西部”的战略，在东部老区必须依靠科技进步，开辟勘探新领域，寻找新的发展途径。为此，中国石油天然气总公司（CNPC）在1996～1997年间，多次组织专家论证，借鉴国外大型含油气盆地的勘探经验，结合中国东部石油地质特点，分析得出了发展东部陆上勘探有两个战略方向：即加强老区复杂隐蔽油气藏的滚动勘探开发和开展深层领域的研究与探索。正因为如此，总公司决定，将“中国东部深层石油地质综合研究与目标评价”，作为“九五”期间重大科技工程项目之一，为将来发展深层勘探做好技术储备。

东部深层项目按照石油地质基础研究、方法技术攻关与勘探目标评价相结合的原则，精心设计、严密组织、深入细致地进行综合研究。三年多来，在科技局、项目各级负责人及全体研究人员的共同努力下，取得了优异的科研成果，实现了在理论、方法上有创新，科研成果向生产力转化及时，油气勘探有充分的科学依据支撑，深层勘探取得重大进展的预期目标。

我们相信，在东部深层项目研究成果基础上，经过编者与执笔者进一步加工提炼、编写成的《中国东部深层石油地质学丛书》，一定能在传播知识、开阔思路、深化东部深层研究和发展东部深层油气勘探等方面起促进作用，成为广大读者的良师益友。

傅诚德　罗治斌

2001年10月10日

Foreword

From the 1990s, petroleum exploration has become intensive in the maturated areas for oil production in East China. More and more oilfields in small and middle scales were found but their total reserve increased slowly. In order to carry out the strategy of Chinese petroleum industry "to stabilize oil production in East China, and to get progress in West China", it is a must to depend upon the achievements of modern science to find new areas and new ways for petroleum exploration. In 1996 – 1997, After several times of expert consultation, China National Petroleum Corperation (CNPC) decided to speed up the petroleum exploration in onshore areas of East China using the advanced experience of Western countries for reference. Two decisions were made: one is to intensify the petroleum exploration on complex subtle oil pools; another is to deploy research and exploration on deep horizons. As result the research project "Integrated Research of Petroleum Geology and Target Evaluation of the Deep Horizons in East China" was set as one of the important science and technology projects in CNPC for the sake of guiding the future exploration in deep horizons.

The research project was elaborately planned and well organized according to the integration of fundamental study of petroleum geology, technique and methods of exploration, and target evaluation and selection. Under the leadership of the *administration of the Bureau of Science and Technology*, CNPC, all the researchers worked hard for the past three years and have gotten some outstanding achievements. There are innovations in theory and methods. The research guided the exploration in real time and some important findings have been made in deep horizon exploration. And the expected goal has been fulfilled satisfactorily.

We believe that through the authors' systematically summarization of the research achievements, the book named "*Series of Petroleum Geology of Deep Horizon in East China*" will play an important role in knowledge transmission, mind opening, intensive study and petroleum exploration of deep horizons in East China. This book will be helpful to the readers in reference for the exploration of oil and gas in the deep horizons.

Fu Chengde, Luo Zhibin

October 10, 2001

前　言

如同人类认识事物的规律由浅入深、由表及里一样，油气勘探也是由地表向地下、由浅层向深层发展。随着人类对油气资源利用的需求不断增长，地球物理勘探技术、钻井技术与开采技术的不断提高，许多埋藏较浅的油气田已基本探明和投入开发，一些老油区为了维持储采平衡和寻求新的发展途径，势必会开展深层石油地质研究与油气勘探。据不完全统计，世界上已有70多个国家进行了深度超过4000m的油气钻探。有80多个盆地和油区，在4000m以下的层系中发现了2300多个油气藏，共发现深层大油气田（可采储量大于6850×10^4t和$850\times10^8m^3$）30多个，分别占世界大油田和大气田储量的7.8%与3.1%（周庆凡等，1992）。已知最深的气藏是美国西部盆地阿纳达科凹陷米尔斯兰奇气田，下奥陶统碳酸盐岩气藏埋深7663～8083m，储量达$365\times10^8m^3$，单井日产气$6\times10^4m^3$；最深的油藏是美国墨西哥湾密西西比三角洲的列克—华盛顿湖油田，深达6540m。

勘探实践证明，无论新区或老区，在一些沉积岩巨厚的大型沉积盆地内，开展深层勘探都是有作为的。例如，20世纪80年代初，滨里海盆地田吉兹巨型油田的发现，就是深层勘探的重大成果。田吉兹油田面积达$400km^2$，油藏高度达1700m，一般埋深3900～5600m，石油和溶解气地质储量分别为35×10^8t和$1.3\times10^{12}m^3$，其深部勘探范围还可能扩大。又如90年代早期，在哥伦比亚科迪勒拉山前的亚诺斯盆地，经过近50年的徘徊不前之后，在复杂的逆掩构造带上钻探的Cusiana－2A井，在井深4227～4450m钻遇白垩系与古新统海相砂岩产层，初期日产油900t，天然气$62\times10^4m^3$，终于打开了局面。1994年，在乌兹别克的费尔干纳盆地，从经营了100多年的南部老油区，向北部天山山前逆掩带上转移，在白垩—第三系中据称发现了日产2×10^4t的高产井，埋深在3500～5000m。很多接近枯竭的老油区，通过深层勘探打开了新局面，呈下降趋势的油气产量再次回升，例如美国的二叠盆地和前苏联的格罗兹内等老油区。

自20世纪70年代以来，我国先后在渤海湾、四川、塔里木、准噶尔等十来个沉积盆地中进行深井钻探。最深的钻井为塔里木的塔参1井，井深7200m。最深的油藏为塔中的东河塘石炭系砂岩油藏，油藏底界深5756m；最深的气藏为四川川东的高峰场石炭系灰岩气藏，气藏深5450～5470m。到目前为止，已先后在准噶尔石西，塔里木塔河、轮南，四川五百梯，渤海湾桩西、文留、千米桥等发现了一批探明油气储量在5000×10^4t以上的油气田，初步展示了我国深层油气勘探的良好前景。

俄罗斯的石油地质学家，得益于该国在许多大型盆地都进行系统的区域勘探和基准井、参数井与深探井等钻探，获得了比较好的勘探实践经验，以及他们比较注重基础理论方面的研究，因此，在深层石油地质的研究上位居世界的前列。先后有《深层油气藏形成与分布》（С·П·马克西莫夫等，1988）、《对深层勘探前景的预测》（А.И. 索罗托夫等，1989）、《深层烃矿藏的形成和分布》（Р.Г. 萨姆维洛夫等，1998）等著作问世，并被翻译成中文出版，曾在我国石油地质界广为流传。相比之下，欧美各国受资本投入追求高额利润的机制影响，在深层勘探上的投入变化较大，在深层石油地质研究方面发表的专著相对较少。

1989～1990年，根据中、苏经济贸易、科技委员会科技合作常务委员会的议定书和两

国石油工业部代表窦炳文、A.И. 里索夫、胡见义、B.И. 格罗米可，于莫斯科签署的协议，由苏联可燃矿物地质与开发研究所（ИГИРГИ）和北京石油勘探开发科学研究院(RIPED)，组织开展“深层复杂油气藏预测与普查方法”的科研合作项目。中苏双方各派5名专家在对方共同工作3个月，对冀中坳陷和滨里海盆地南部深层地质构造、储集层、生油岩和油气地球化学等研究成果与方法进行系统交流和讨论，并按统一提纲，共同编写了《深层油气藏储集层与相态预测》一书（刘淑萱，1992），揭开了我国深层石油地质研究的序幕。

1997～2000年，中国石油天然气总公司（CNPC），根据未来勘探势必由中浅层向深层发展的趋势，确定“中国东部深层石油地质综合研究与目标评价”为重大科技工程项目。该项目在科技主管部门领导下，由北京石油勘探开发科学研究院牵头，组织大庆、吉林、辽河、冀东、大港、华北等油田，石油大学、大庆石油学院、长春科技大学等单位，首次系统开展了以松辽、渤海湾盆地为主体的中浅层主力含油层系以下的深层石油地质综合研究与有利区带评价。经过三年多的努力，不仅取得了丰硕的石油地质研究成果，而且在深层勘探中应用先进技术，勇于探索，发现了千米桥、马东东、曙光、欧利坨子、信安镇北、束鹿南、老爷庙、北堡、昌德、大房身、小城子等一批有重要意义的油气田（藏），推动了我国东部深层石油地质研究与油气勘探全面深入的发展。

《中国东部深层石油地质学丛书》一书，正是在“中国东部深层石油地质综合研究与目标评价”项目及所属课、专题研究成果的基础上，经过编著者的归纳综合与深化提高形成的专著。该书的主要论点如下：

（1）中生代以来，中国东部陆缘区先后受古亚洲洋构造体制、滨太平洋—古亚洲洋叠加构造体制与滨太平洋构造体制控制，形成了三叠纪内陆坳陷，早、中侏罗世火山—含煤断陷，晚侏罗世至白垩纪火山—断陷、坳陷与第三纪火山—断陷、坳陷，共四期成盆旋回。新形成的裂谷盆地叠覆和改造了早期的残留盆地。

（2）松辽与渤海湾盆地深层属走滑伸展与正反转叠加复合构造。其中，松辽盆地为早白垩世断陷构造层与断陷—坳陷构造层叠覆，深层构造样式主要为走滑伸展与正反转叠加复合构造；渤海湾盆地早第三纪为四套亚裂陷构造层既叠加又转移的叠加复合构造，深层构造样式主要为早第三纪走滑伸展构造和为其所改造的古生界挤压构造。

（3）松辽与渤海湾裂谷深部为多元对应的地壳层圈构造：上地壳为裂陷、坳陷构造；从上地壳延伸至中、下地壳软流层为犁式断裂带、逆掩断裂带和大型拆离带；对应于裂陷带为中、下地壳内具低速高导特性的软流层、莫霍面隆起与热液底辟构造；与盆地沉降中心对应的上地幔软流圈隆起。地壳深部构造控制了裂谷盆地的热扩张、热沉降与沉积物的热变质。

（4）渤海湾盆地深层，第三系沙河街组、孔店组为主要烃源层，藻源相、混源相为最好的生烃相带；石炭—二叠系山西组、太原组煤系生烃，流水沼泽相与深沼芦苇相为有利生烃相带；奥陶系峰峰组、马家沟组碳酸盐岩具一定的生烃能力，局限海相为有利生烃相带。松辽盆地深层沙河子组与营城组含煤湖沼相沉积为主要烃源岩；未变质的上二叠统湖相沉积具生烃潜力。

（5）东部裂谷深层在高温、高压条件下，生烃速率变慢，液态窗向深处下移；当地层水加入，可使液态烃产率增高、气态烃产率降低。东部裂谷下伏的古生界烃源岩普遍存在二次生烃与迟滞性，迟滞性随二次生烃起始成熟度升高而增加，当起始成熟度位于生油窗内(R_o=0.9%左右)，二次生烃量大于或等于一次连续生烃量；印支—燕山期古生界未被深埋，热变质程度较低（R_o<0.8%），但在喜山期显著深埋的古生界有利于二次大量生烃。

(6) 东部裂谷白垩—第三系深层，碎屑岩次生孔隙发育带主要形成于晚成岩 A_1、A_2、B 三个亚期。储集性能主要受沉积岩相、矿物成分、颗粒成熟度、地温梯度、酸性水溶液、热对流循环等多种成因机制控制。深层高温、高压烃源岩内的浊积体，因粒级较粗和孔隙流体的高压异常，储集性能好。深层特殊类型的储层（火山岩、碳酸盐岩等）经溶蚀与构造缝改造，可形成好的储集体。

(7) 东部裂谷深层存在两大成藏体系。其中，裂谷深层白垩—第三系高温、高压生烃灶—泄压通道—有效储集体圈闭成藏体系占主要地位。它包括：①一次运移，早期充注的高压岩性油气藏；②垂向运移为主，多期充注、多期成藏的断裂构造油气藏；③侧向运移为主，多期充注、多期成藏的潜山与地层不整合油气藏。而裂谷内下伏基岩在适当条件下，形成古生界原生油气藏成藏体系。古生界在喜山期显著深埋，热变质程度中等到高（R_o=1.0%～1.5%左右），有利于二次生烃；古生界晚期大量二次生烃，并充注到古生界内部的裂缝—孔洞储集空间内，有利于古生界自生自储原生油气藏的晚期成藏与保存。部分古生界二次生成的烃类，运移到上覆的中、新生界的圈闭内，形成古生中储或古生新储型油气藏。

(8) 东部裂谷深层具有多套好烃源岩，圈闭形成较早，受异常高压封闭，一般均有利于成藏。因此，油气富集高产的关键是储集体的规模与有效储集空间的发育程度。所以，评价和预测深层内经成岩作用、溶蚀和构造作用改善的大型储集体至为关键。

(9) 东部裂谷深层烃相态的分布，总体上受有机母质类型、时温补偿原理与超压对生烃速率的抑制作用控制。在松辽盆地深层下白垩统，主要赋存高成熟和高温裂解的有机气藏(油型或煤型)，并有无机气混入；油藏为辅。在渤海湾盆地第三系 3500m 以下的地层中，主要赋存轻质油藏与凝析油气藏；古生界原生油气藏主要产出甲烷气等，油藏较少。

《中国东部深层石油地质学丛书》共分三卷：第一卷，《中国东部深层石油地质》；第二卷，《东北地区深层石油地质》；第三卷，《渤海湾盆地深层石油地质》。这三卷分别从不同的范畴论述了中国东部深层石油地质的理论认识与油气形成及分布规律，并为发展东部油气勘探提供了新的视角和新的研究方法。三卷书脉络相通，自成系统；既有一定的共性，又各具特色。

编者本着着重论述东部深层石油地质新理论认识与新研究方法的技术思路，对东部深层项目的研究成果进行了全面系统的综合分析与抽提归纳；对本书论述的主要内容，作了进一步的深化和提高。经过编者多次筹划、统稿与修订，以及执笔作者、出版者的辛勤劳作，前后历时近两年，终于迎着 21 世纪的朝阳，使《中国东部深层石油地质学丛书》问世。

欣逢此书出版之际，谨向“中国东部深层石油地质综合研究与目标评价”项目的倡导者、组织者、支持者、全体研究者和《中国东部深层石油地质学丛书》的全体编著者，所作出的贡献和付出的辛劳，致以诚挚的谢意。特别需要提出，在本项目研究过程中，始终得到傅诚德教授、罗治斌教授的大力支持，在此深表谢意。同时，对中国科学院刘光鼎院士、马宗晋院士、戴金星院士、田在艺院士与丁贵明教授、石宝珩教授、关德范教授、金之钧教授、赵政璋教授、箫德铭教授、刘德来高级工程师与李先奇博士等多年来给予的鼓励、支持和帮助，在此一并致谢。

编　者

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Preface

Just like the mankind to explore the nature in the way of probing from the outside to the inside, petroleum exploration makes progress in the same way from surface to subsurface, and then from shallow horizons to deep ones. With humans increasing demand for oil resources, and the emerging of advanced technologies of geophysical exploration, drilling and production techniques, most of the oil reservoirs in shallow horizons have been identified and brought under extensive production. In some of the oil production maturated areas, it is nature for explorer and researcher to focus on the targets in the deep horizons in order to find new reserves. Till now there are more than 70 countries in the world have drilled wells into the horizons below 4000 meters. About 2300 oil and gas reservoirs bellow 4000 m have been found in 80 basins and petroliferous zones. The total number of big or giant oil or gas fields of this kind (with recoverable reserve greater than 68.5 million ton of oil and 85 billion cubic meters of gas) amounts to more than 30, about 7.8% and 3.1% in all of the big or giant oil and gas fields in the world respectively (Zhou Qingfan *et al*, 1992). The deepest gasfield in the world known till present is Mills-Ranch gasfield which suits in Anadarko Depression, West American Basin with a production about 60,000 cubic meters one well per day and a gas reserve about 36.5 billion cubic meters from a carbonate reservoir of lower Ordovician in the depth from 7663m to 8083m. The deepest oilfield known till now is Washinton Oilfield in Mississippi Delta, Mexico Gulf, US, with a depth about 6540m.

It is proven by the activity of exploration that petroleum exploration in the deep horizon will be fruitful in some of the big sedimentary basins with thick sediments, whether in virgin area or maturated regions. For example, the discovery of Tianjiz giant oilfield in Pricaspian Basin in the early 1980's, 20 Century was one of the great achievement of petroleum exploration in deep horizons. This oilfield is with an area about 400 km^2, height of oil column about 1700 m, depth in the range from 3900 to 5600m. Its geological reserve of oil and dissolved gases are 3500 million ton and 1300 billion cubic meters. And there still is the possibility to explore in its deep horizons. The second example would be in Aires Basin in the front of Colombia Cordilleran Mountain. After about 50 years' lingering, the Cusiana-2A well drilled on a complex thrust belt in early 1990's gave a breakthrough in oil exploration from Cretaceous and Paleocene marine sandstones in the depth from 4227 to 4450m with an initial production of oil about 900 ton and gases about 620 thousand cubic meters per day. Another example is from Fergana Basin, Uzbekstan, which is an old oil production region with a history of more than 100 years. In 1994, the petroleum exploration moved to the thrust belt in the font of Tianshan Mountain, and it is said a high production well with 20,000 ton oil per day from Cretaceous-Tertiary in the depth from 3500 to 5000m has been found. Through the activity of exploration in deep horizons, oil production in many maturated regions increased again; otherwise they would decrease in production because of their previous nearly depleted oil reserves. Some of the oilfields in Permian Basin in US and Groznyy Basin in former Soviet Union are good examples.

From 1970's, some deep wells have been drilled in more than 10 basins in China, including Bohai Bay, Sichuan, Tarim, Junggar Basins. The deepest well is Well Tacan-1 in Tarim Basin with the depth of 7200 m. The deepest oil pool is in the Carboniferous sandstone of Donghetang Formation in the Central Depression, Tarim Basin, which is with an oil-water contact about 5756m. The deepest gas pool is in Carboniferous limestone of Gaofengchang Formation in the eastern part of Sichuan Basin, depth ranging from 5450 to 5470m. Till now, some of the oil and gas fields from deep horizons with proven reserve more than 50 million ton have been found in several regions including Shixi of Junggar Basin, Tahe and Lunnan of Tarim Basin, Wubaiti of Sichuan Basin, Zhuangxi, Wenliu and Qianmiqiao of Bohai Bay Basin, all of them showing a promising future for the exploration in deep horizons in China.

Russian petroleum geologists are the pioneers in the field of petroleum geology of deep horizon in the world because they have sound experiences in these aspects through systematic explorations including regional investigation, datum wells, parametric wells and deep wells drilling in many big or giant sedimentary basins, and their great effort in the fundamental theoretical research. There are many famous writings on the petroleum geology in deep horizon, such as *The Formation and Distribution of Oil Reservoirs in Deep Horizons* (C.П.Maksimov *et al*, 1988), *Prediction on the exploration prospect in deep horizons* (A.И.Sorotov *et al*, 1989), *The Formation and Occurrence of Deep Hydrocarbon Deposits* (P.Г.Samuwelov *et al*, 1998). Their translations in Chinese once became very popular in the circle of petroleum geology in China. Contrast to the great achievements in Russia, the western countries including North America and Europe have few publications on deep exploration due to their profit-oriented investment policy and great fluctuations in investments.

In 1989-1990, according to the protocol between the Science and Technology Cooperation Standing Committee of Economic, Commercial and Science Committee of China and former Soviet Union, and the agreement signed by the representatives Dou Bingwen, Hu Jianyi from China, and A.И.Lisov, B.И.Geromic from CCCP, the ИГИРГИ and RIPED cooperated on the research project "The Prediction and Prospecting on the Complex Oil Reservoirs in the Deep Horizon". Five experts from each country work together in China and CCCP for six months to exchange and discuss on the research methods and achievements in the geological texture, reservoir, source rocks and organic geochemistry study in Jizhong Depression of Bohai Bay Basin in China and southern part of Pricaspian Basin in CCCP. As a result of this cooperation, a book named *Prediction on Reservoir and Phase of Petroleum in Deep Horizons* publicized (Chief Editor Liu Shuxuan, 1992). And this book became the prologue of geology research on petroleum in deep horizons in China.

In 1997 – 2000, China National Petroleum Corporation (CNPC) determined the project named "Integrated research of petroleum geology and target evaluation of the deep horizons in East China" as one of the important science and technology projects in CNPC. Under the administration of the Bureau of Science and Technology, CNPC, the Research Institute of Petroleum Exploration and Development (RIPED) organized several partners, including Daqing, Jilin, Liaohe, Jidong, Dagang and Huabei Oilfields and University of Petroleum, Daqing Petroleum Institute, Changchun University of Science and Technology, to systematically research for the first time on the integrated petroleum geology and favorable petroliferous belt selection of the deep horizons, mainly in the Songliao and Bohai Bay basins. Through 3-years' hard work, we have gotten two outstanding achievements. One is the plentiful and substantial harvest in theoretical research of petroleum geology of deep horizons. The second is that we found series of important oilfields by the usage of advanced technologies in the deep horizon exploration. These oilfields are as follows: Qianmiqiao, Madongdong, Shuguang, Oulituozi, Xinganzhengbei, Shulunan, Laoyemiao, Beipu, Changde, Dafangshen and Xiaochengzi oilfields. This project has promoted a comprehensive progress in the study of petroleum geology and exploration in the deep horizons in east China.

The book named *The Series of Petroleum Geology of Deep Horizons in East China* is a monograph by highlighting the main achievements of the project and its diverse topics. It's main conclusions are as follows:

1. From Mesozoic, the continental margin in east China was controlled by three successive tectonic mechanisms: paleo-Asiatic ocean tectonic regime, Marginal Pacific tectonics surperposed by palea-Asiatic ocean tectonics regime and Marginal Pacific tectonic regime to from the intra-continental depression in Triassic, volcanic-coalbearing faulted depression in Early-Middle Jurassic, volcanic-faulted depression in Late Jurassic-Cretaceous period, and volcanic-faulted depression in Tertiary. The lately formed rift basins superimposed upon and altered the previously wrecked basins.

2. In the deep horizons of Songliao and Bohai Bay basins, strike-slip-extensional structures were superposed by the normal reverse structures to form a structure complex. In Songliao Basin, Early Cretaceous faulted rift tectonic layers and faulted depression tectonic layers compose the superpositions. It's structure styles are mainly strike-slip and extensional structure superposed by normal reverse structures. In Bohai Bay Basin, there are four sub-rift tectonic layers of Early Tertiary, they superpose in different places over the basin. Its structure styles in deep horizon are mainly the strike-slip-extensional structures of Early Tertiary and the Paleozoic compressive structures modified by the Tertiary tectonic movements.

3. In the deep crust of Songliao and Bohai Bay basins, there are several layered circle textures with multiple origins. The upper crust is in the state of rift-depression structures. From upper crust to flowage layer of middle and lower crust, there are listric normal faults, thrust faults and detachment belts. The depressions in mirror image correspond to the flowage layer, the uplift of Moho surface, the upward plugging of thermal fluids, all of them are with the properties of low velocity and high conductivity. The depression in the center of the basin corresponds to the uplifts of flowage layer in the upper mantle. The deep crust structure controlled the thermal extension, thermal subsiding, and thermal metamorphosis of the sediments.

4. In the deep horizons of Bohai Bay Basin, there are several types of source rocks in different formations. The shale and mudstone in Shahejie Formation and Kongdian Formation of Tertiary are the main source rocks with algae and the mixture of humus and sapropel as the best facies

for hydrocarbon-generation. The coal measures of Shanxi and Taiyuan Formations in Carboniferous-Permian are source rocks with the reedy organic facies in swamp with following water and deep swamp as the best hydrocarbon-generating organic facies. The Ordovician carbonate rocks in Fengfeng and Majiagou Formations have the potential to generate hydrocarbon with the restricted sea organic facies as the favorable zone to generate hydrocarbon. In the deep horizon in Songliao Basin, the sediments from coaly swamp in Shahezi and Yingcheng Formation are the main source rocks. The unmetamorphized lacustrine sediments of Upper Permian have some potential for hydrocarbon generation.

5. Under high temperature and pressure in the deep horizon of rift basin in East China, the hydrocarbon generation slow down and the generation window migrate downwards. With the help of formation water, the productivity of liquid hydrocarbon increases while that of gas decreases. There are phenomena of secondary hydrocarbon generation and tardiness of generation in the Paleozoic source rocks bellow the Tertiary rift basin. The tardiness gets later as the initial maturation increases. When the initial maturation is in the range of oil generation window ($R_o = 0.9\% \pm$), the amount of secondary generation will greater or not less than that of the primary successive generation. So the Paleozoic which did not undergo deep burial in Indosinian-Yanshan Period and was with lower maturation ($R_o < 0.8\%$) would be favorable for extensive hydrocarbon generation during its deep reburial in Himalayan Period.

6. In the deep horizon of Cretaceous-Tertiary in East China, the zones of secondary porosity development in clastic rocks are mainly formed in the stage A_1, A_2 and B of late digenesis period. Reservoir properties are controlled by many factors including sedimentary facies, mineral composition, granular maturation, geothermal gradient, acidic water solution, thermal convection and circulation. The turbidite sand bodies wrapped in the source rocks with high temperature and pressure in the deep horizon are good reservoirs due to their coarse grain size and overpressured pore fluids. Through the modification of mineral dissolution and tectonic fracturing, some special rocks such as volcanic and carbonate rocks may become excellent reservoir rocks.

7. There are two oil generation-migration-accumulation systems in the deep horizon of rift basins in East China, of which the system that include the oil generation kitchen in Cretaceous-Tertiary with high temperature and high pressure, the pass way of fluid leakage, and effective reservoir rocks, is of predominant. This system can be divided into several subsystems. One is the lithologic oil pool with early infill through primary migration. The second is fault block oil pool with multiple stages of oil infill and dominantly vertical migration. The third is the pool in the origin of buried hill and in unconformity with multiple infill and lateral migration. Under favorable conditions, the Paleozoic basement rocks of the rift basin can form the oil system of primary oil pools by themselves. In the Himalayan Period, the Paleozoic underwent significant burial, and its organic maturation reached moderate to high stages ($R_o = 1.0\% - 1.5\% \pm$) and was favorable for secondary petroleum generation. Large amount of oil generated in this period infill the fracture and pore in the Paleozoic rock and formed primary oil pools, which were favorable for preservation till the present time. Some of the oil generated by Paleozoic might migrate to the overlaying Mesozoic and Cenozoic traps to form oil accumulations.

8. There are several series of good source rocks in deep horizons of East China. Most traps formed before oil generation. Together with the influence of overpressure in the source rock, they are generally favorable for petroleum accumulation. So the key to form large accumulation is the reservoir, its size and effective volume for fluid storage. The evaluation and prediction of large-scaled reservoirs, which got good storage property through digenesis, mineral dissolution, and tectonic fracturing, are critical to the oil exploration in deep horizons.

9. The occurrence of hydrocarbon happening the deep horizon of the rift basins in East China is generally controlled by the type of organic matter, the role of time and temperature for organic reaction, and the retardation to petroleum generation caused by the overpressure in deep zones. In Lower Cretaceous formation of the deep horizon in Songliao Basin, petroleum is mainly in gas phase in the origin of high maturation and thermal cracking (oil or coal type), and mixed with some inorganic gases. In Bohai Bay Basin, petroleum in the deep horizon of Tertiary with the depth exceeding 3500m is mainly light oil and condensate gas. The primary Paleozoic petroleum pools are chiefly composed of CH_4, CO_2 and minor amount of oil.

Series of Petroleum Geology of Deep Horizon in East China are composed of three volumes. Volume One is Petroleum Geology of Deep Horizon in East China. Volume Two is Petroleum Geology of Deep Horizon in Northeast China. Volume Three is Petroleum Geology of Deep Horizon in Bohai Bay Basin. They dissertate on petroleum formation and occurrence in East China, and propose some new ideas and methods for petroleum exploration in these regions. Each book is unique but they have some characteristics in common.

Under the chief editors' guidance to stress the new theory and new methods we put forth in the project on petroleum geology of the deep horizons in East China, all the authors for their diligence and willingness to systematically summarize the fruits of their studies in specific projects. The chief editors sincerely cooperate with the authors and publishers, and spent nearly two years to comprehensively compile the papers into a unique series as the integration of our research. Eventually in the early days of the 21st Century, the book named Series of Petroleum Geology of Deep Horizons in East China comes out!

At this precious moment, the editors are indebted to the proposers, organizers, supporters, and all the researchers of the project Integrated research of petroleum geology and target evaluation of the deep horizons in East China', and all the authors of the Series of Petroleum Geology of Deep Horizons in East China, for their contributions and diligent work. Specifically, the editors wish to thank professors Fu Chengde, Luo Zhibing for their great Support. In the Same Way to thank Liu Guangding, Ma Zongjin, Dai Jinxing, and Tian Zaiyi, academicians of Chinese Academy of Science, and professors Ding Guiming, Shi Baoheng, Guan Defan, Jin Zhijun, Zhao Zhengzhang, Xiao Deming and senior engineer Liu Delai, Li Xianqi for their help and support.

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