

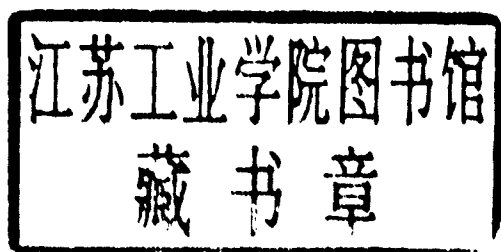
何自新 等著

# 鄂尔多斯盆地 演化与油气

石油工业出版社  
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# 鄂尔多斯盆地演化与油气

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## 内 容 提 要

本书从活动论、阶段论、转化论和构造迁移论,特别是从以活动论为核心的新构造观出发,较全面、系统地论述了稳定的鄂尔多斯地块不同地史阶段盆地的构造特征、沉积环境、岩浆活动、断裂变形和演化过程及其在时、空上的相互联系、移位分布、叠置关系和形成机制,以及与油气富集和分布的关系。本书在盆地构造变形、断裂与裂缝相关性分析及其与油气分布和富集规律等方面有许多新的认识,并对该盆地新区块、新层系、新类型和新领域的油气勘探具有重要指导意义和实际价值。

本书可供从事石油地质、煤田地质、地球物理等专业的科研、生产和教学人员参考。

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## 序

鄂尔多斯盆地是我国最早发现油田的盆地之一，特别是新中国成立以后，经过几代石油人的艰苦创业、拼搏进取和科技创新，从下古生界至中生界均发现丰富的油气资源，油气勘探取得了举世瞩目的成就。截至 2001 年底，仅长庆油田石油探明地质储量超过  $10 \times 10^8 \text{t}$ ，在陕北发现了靖安—安塞达 6 亿吨级大油田，在陇东新发现了储量超亿吨的整装区块；天然气勘探在靖边、苏里格、榆林和乌审旗探明 4 个超  $0.1 \times 10^{12} \text{m}^3$  的古生界含气区块，其中苏里格气田地质储量为  $0.6 \times 10^{12} \text{m}^3$ ，为我国最大气田。由于日新月异的勘探新方法、新技术和新理论的出现，在广泛实践的基础上，对鄂尔多斯盆地进行一次全面系统的总结和理论认识上的进一步深化是必要的。尤其是利用以活动论为核心的新构造观对该地区油气富集规律、油藏形成特点的地质构造背景的分析研究，不仅对深化老油气区的认识和开拓油气新地区、新领域、新类型和新的勘探深度具有实际价值，而且亦对本区乃至整个中国大陆构造变形的理论研究提供了新资料、新思路。因此，本书在理论研究和实际价值等方面均具有重要意义。

全书重点追溯了鄂尔多斯盆地地壳漫长、复杂的构造演化历史，建立了不同历史阶段的基本构造格局和不同属性盆地的沉积格架及其组合与分布。包括在不同历史时期所形成的断裂构造样式和构造形迹的特征及其在时间上的相互联系与发展，在空间上的相互叠置与位移分布。这对于深化认识盆地的形成与发展的基本规律和大陆地壳变形特点的地球动力学背景，以及油气富集与分布规律，特别是跨时代的油气运移、聚集与分布规律的研究，都具有十分重要的实际价值。

从对基础资料的分析出发，作者以阶段论和转化观点，对盆地的断裂构造带进行了归纳、论证和总结，从而认为该盆地在不同历史时期均经过复杂、多期交替挤压、拉张过程。其中断裂在盆地变形、变位中扮演了重要角色。现今盆地是多期次、多成因、多层次滑覆与推覆的构造动态发展组合，这是本区构造地质特色。作者特别强调了盆内断裂在平面上的分区、分带性及其与褶皱共生性，以及在纵向上的分层、分型性。这一认识对于油气赋存规律和指导勘探具有重要理论意义和实用价值。

本书在对盆地内部断裂重新厘定，盆地原型历史分析和构造反转变形应力分析以及油气聚集与分布规律等方面有许多新见解。认为菱形基底断块的存在是鄂尔多斯盆地多个原型盆地叠置并存及沉积—构造差异的基本原因。除边缘外，其主体主要表现为长期稳定的升降运动并伴有微弱断裂活动，因而构造与沉积分异不明显。构造上的稳定性造成古生界海相白云岩、石灰岩、膏岩互变、交错；陆相砂、泥岩交替、混杂。以不整合面为重要标示的沉积上的叠加，导致多油气源岩和多种生储盖组合。以这种石油地质条件为背景的油气聚集势必决定其主要有效圈闭类型为以不整合面上下的地层、岩性（上古生界和中生界）和风化壳等大型的地层、岩性（下古生界）油气藏为主，且储集层具有低孔、低渗、低压的特点，但规模小、切割浅、而密度大的断裂（缝）对油气运移与聚集，特别是高产起到决定性作用，这一重要认识是符合本区实际的。

总之，本书是生产、科研相结合的劳动结晶，实际资料丰富，可信度高，不仅对该盆地

石油地质研究具有指导意义和实用价值，而且对国内外油气聚集规律研究和大地构造变形研究也是一部不可多得的珍贵参考资料。为此，在该书出版之际我谨向辛勤劳动的编者致以衷心的祝贺。

中科院院士 马宗晋

2003年5月

## Preface

Ordos Basin is one of those where oilfield is discovered at the earliest time. After the foundation of new China in 1949, the great efforts have been made to study the strata of lower Paleozoic and Mesozoic in which oil and gas resources are rich. The achievements in the oil and gas exploration attract worldwide attention. By the end of 2001, the proven oil – in – place geological reserves of Changqing Oilfield exceed one trillion tons, including Jingan – Ansai oilfield in Northern Shaanxi Province, where over 600 million tons reserves were detected; and an integrated block with over 100 million tons reserves in Eastern Gansu Province. Four gas – bearing blocks of Paleozoic each with over 100 bcm (billion cubic meter) gas reserves were proven in the regions of Jingbian, Suligemiao, Yulin and Wushenqi. Geological reserve of gas in the Sulige block is up to 600 bcm that is the largest gas field in China. With the achievements in exploration method, technology, it is necessary to sum up the practice of oil and gas exploration in Ordos Basin in order to deepen the correlative theory. In particular, application of an advanced theory of structural analysis based on the mobilism to explore the rules of oil and gas enrichment and the geological and structural background for the reservoir formation is practically significant. It is favorable not only to deepen the knowledge about the proved oil and gas fields, to exploit a new working area, new type and new exploring level, but also to the theoretic study on structural deformation in China mainland by offering new materials and advanced train of thoughts. This book, therefore, is of great significance in both theory and practice.

Based on the study of the long and complicated tectonic evolution history in Ordos Basin, the basic tectonic frameworks, sediment frames of various basins, and their combination and distribution are established in this book. This includes the characteristics of fault types and structural features formed in the course of their evolution, their correlation and development in time and correlative overlapping and replacement in space. These results are valuable in further understanding of the formation and development of the basin, the geodynamic setting of continental crust deformation, the principal of oil and gas enrichment and their distribution, especially the study on migration, accumulation and distribution of a time – transitional oil and gas field.

Through analysis of original data, the author summarizes the features of fault zones in the basin from the viewpoint of development with stages and tectonic inversions. It is pointed out that the basin has undertaken complex multiple alternative compressions and extensions in different historical stages, during which the faults played the important role in the deformation and replacement of the basin. The basin at present is characterized by multi – phases of formation, various origins and alternative sliding and napping structures in different levels. The author especially emphasizes a plane areal and zoning distribution of the faults within basin and their relation with folds, as well as their stratified and typified feature on profile. The above

consideration is of important theoretical significance and practical value both to the knowledge of oil and gas accumulation, and the exploration.

New achievements reported in this book include the results from the study aspects of re-ordering the inner-basin faults, the historical analysis of original basin, the stress analysis of tectonic reversal, and the restricting the oil and gas accumulation and distribution. It was believed that the presence of several rhombus fragments of basement is an essential reason for the overlapping of several original basins in Ordos basin, and for the differences in their sediment and structure. Except the marginal area, main part of the Ordos basin shows a long-lasting stable elevation and subsidence without remarkable fault disturbing which results in a slight differentiation either in sedimentation or in structure. The tectonic stability brings up a translating and crossing layering in Paleozoic marine dolomite, limestone and gypsum, and an alternating and mixture texture in continental deposits of sand and mudstone. Overlapping deposits marked by unconformity surface leads to multiple oil and gas source rocks, and to variable source-reservoir-cap bed combinations. Accumulation of oil and gas in the geologic background mentioned above should result in such an available trap where the major stratigraphic and (or) lithologic (lower Paleozoic) pool must be suit in the stratum, lithology (upper Paleozoic and Mesozoic) and weathering deposit above and beneath the unconformity surface. It is critical for a high oil and gas productivity that the reservoirs should be also in low porosity, low permeability and low pressure, and the fractures should be small, shallowly cutting and in high density. The above considerations are important and are consistent with the situation in practice.

To sum up, this book combines the results from both exploration experience and scientific research with abundant and reliable materials. It's not only of instructive significance and practical value to the petroleum geology analysis in the basin, but also of a valuable reference to the study on the accumulation rules of oil and gas and tectonic deformation analysis in China and overseas. For the author's painstaking, I would like to express my sincere congratulation before the book is published.

Academician of Chinese Academy  
of Sciences Ma Zongjin  
May 2003

# 前 言

鄂尔多斯盆地是我国第二大含油气盆地，以结构简单、构造平缓、沉降稳定、地层整合而闻名。更以油气藏隐蔽、复杂和低品位、低渗透、低产量、低效益而著称。近年来，随着油气勘探方法、技术的进步和地质认识的深化，对盆地的认识每年都有一定程度的加深甚至修正。为进一步深化老区和指导新区油气田形成条件和地质规律的认识，促进油气勘探与开发事业向纵深发展，以确保迅速发展的国民经济对油气资源的需求。因此，全面、系统地总结盆地油气勘探的丰硕成果和成功经验，对指导日后的勘探与开发具有重大理论意义和实际价值。

本书在力图全面总结盆地研究新成果的同时，重点对地块内部断裂构造带及其组合的几何学、运动学，以及形成的动力学背景进行了厘定和论证。特别强调了盆内断裂（缝）在平面上的分区、分带性及其与褶皱的共生性，以及在纵向上的分层、分型性特征，及其对不同时代、不同层系和不同相带石油天然气的控制作用。

本书共分三篇，第一篇以断裂构造为主线，从大地构造背景、应力场变更、断裂作用、构造变形、岩浆活动和变质作用以及沉积作用、沉积体系等方面，系统地阐述了盆地演化过程。建立了不同世代、不同属性原型盆地的构造格局、沉积格架和相带分布及其在时间上相互联系和发展及在空间上的移位分布、叠置关系和演化机制。从而明确了一个大型稳定、复合克拉通盆地造就了三套主要烃源岩、四套储集岩系、两个不整合面、三个滑脱面和六大各具含油气特色的构造单元新理念。

第二篇从基本的石油地质条件出发，阐述了生、储、盖及其组合特点和油气运移、聚集机制，以及油气藏形成与分布规律。指出了不整合面的类型、数量、间断时间长短和断裂及相关裂缝类型与油气生成、运移与聚集的关系。

第三篇主要在深化盆地及其油气藏分布规律认识的基础上，对有利的含油气区块和隐蔽的油气领域和类型进行了有益探索，认为盆地勘探层系多、资源潜力大，特别是西缘掩冲带的前缘带，既是盆山耦合带，又是圈闭发育带和油气聚集带，勘探前景十分广阔。

本书适度地引进了当代石油地质构造研究的一些新方法、新概念、新模式和新理论，尽力做到地质与地球物理相结合，造山带与前陆盆地相结合，浅层构造与深层构造相结合，区域构造与局部构造相结合，静态与动态相结合，形成与形变相结合，建造与改造相结合，综合研究含油气盆地断裂的形成与演化和探讨油气生成与富集的地质构造背景及其分布规律，以其发掘那些被掩盖和被隐蔽的油气领域，为油气勘探提供新思路和新观点。

本书由马宗晋院士作序并提出了宝贵的修改、补充意见。参加编写工作的还有杨华、费安琪、付锁堂、王同和、张军及蒋加钰、陈安宁、李良丰、卢金城等。

本书除引用中国石油天然气股份有限公司长庆油田分公司资料外，还引用了陕、甘、



宁、蒙、晋、豫等地矿局、煤田局等单位资料，除在本书具体注明外，在此一并表示谢意。在资料收集过程中，得到了李振亚、方成水、张艳春、何天翼、陈大洪、章贵松、姜卫东等的大力支持，亦在此表示衷心感谢。

谨以此书献给在鄂尔多斯盆地野外跋涉和从事油气勘探、开发研究的地质先辈和同行们。

何自新

2003年3月

## Introduction

Ordos Basin, the second largest hydrocarbon – bearing basin in China, is famous for its simple internal construction, gentle structures, stable depositional history and conformable stratum. Ordos Basin is also well – known by its hidden and complex reservoirs, low quality and permeability, and then for its low products and low economic efficiency. In recent years, with the rapid progress on exploration techniques and methods, the achievement in better understanding of the geological background is made every year. In order to propel the oil and gas exploration and development, and to ensure that the oil and gas reservoirs will meet the needs of the rapid developed national economy, a further understanding on the controlling facts and the geologic – structure relationships of the oil and gas re – accumulating in the investigated and prospective oil and gas fields is indeed needed. It will be a great theoretical and practical significance in the future practice of exploration and development of oil and gas by taking a systematic and overall summary on the achievements and successful experience of the processed explorations.

Besides the comprehensive review of the results from preliminary studies, more attention in this book is paid to confirming and demonstrating the geometry, kinematics and dynamics of the faults and fault systems. Distributions of fault – related fractures in zones, regions or in relation with the associated folds in space, and in stratified oil and gas stratotypes in succession are emphasized that allows to establish a relationship between the various distributions and spatial oil and gas accumulations different in times, strata and faces.

This book consists of three Parts. Part One describes the evolution of the basins systematically following fault development. Aspects of tectonic background, modification of regional stress field, fault development, structural deformation, magmatic activity, metamorphism, sedimentation and depositional system are all stated. Specialized structural pattern, sediment frame and distribution of sedimentary facies are illustrated for individual primary basins that are formed at different stages. Relationship of the basins in times, as well as their transposition and overlapping in space and evolution mechanisms during their formation and reworking is established.

Part Two emphasizes on basic petroleum geology. Following description on the characteristic of the source rocks, oil and gas storages and reservoir traps in the basins, their combination features, mechanisms of hydrocarbon migration and accumulation, rules of the reservoir formation and distribution are demonstrated. Effects of various unconformities and fracture types on hydrocarbon generation, migration and accumulation are also pointed out.

Further research on favorable potential hydrocarbon sources in the Ordos Basin is allocated in Part Three. The studies base on the basin structure and reservoir distribution, it is pointed out that the Ordos basin still has multiple accumulations rich in oil and gas for further exploration. Prospects of exploration are in great promising.

Some modern research methods, new concepts and theories, and new models appeared in present petroleum geological and structural studies are quoted suitably in this book. The author of the book tries to use the data alternately from the geologic investigations and deep soundings to constrain the relations between regional tectonics and local structures, the superstructures with deep-seated structures, the orogenesis and foreland basin evolution, the static and dynamic, and the formation and reworking processes in the Ordos Basin. By the comprehensive study on the fault-related basin development and geologic-structural condition for oil and gas generating, enrichment and distribution, a new train of thought and new viewpoint are made which will be favorable onto further exploration of potential and hidden oil and gas reservoirs in the basin.

## ACKNOWLEDGMENTS

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Quotations of the study results used in this book are from the petroleum exploration of the Changqing Oil-field of Petro China, local geologic and mineral resources bureaus and coal field bureaus of Shaanxi, Gansu, Ningxia, Inner Mongolia, Shanxi and Henan Provinces. Although extra note for the cited data is made in the book, the author would like to thank for all other supports related. Mr. Li Liangfeng, Li Zhenya, Fang Chengshui, Zhang Yanchun, He Tianyi, Chen Dahong, Zhang Guisong and Jiang Weidong are thanked for assisting in collecting relative references.

This book is dedicated to the geologists of old and young generations who have spent their whole lives to the field investigation and petroleum exploration in Ordos.

He Zixin  
March 2003

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