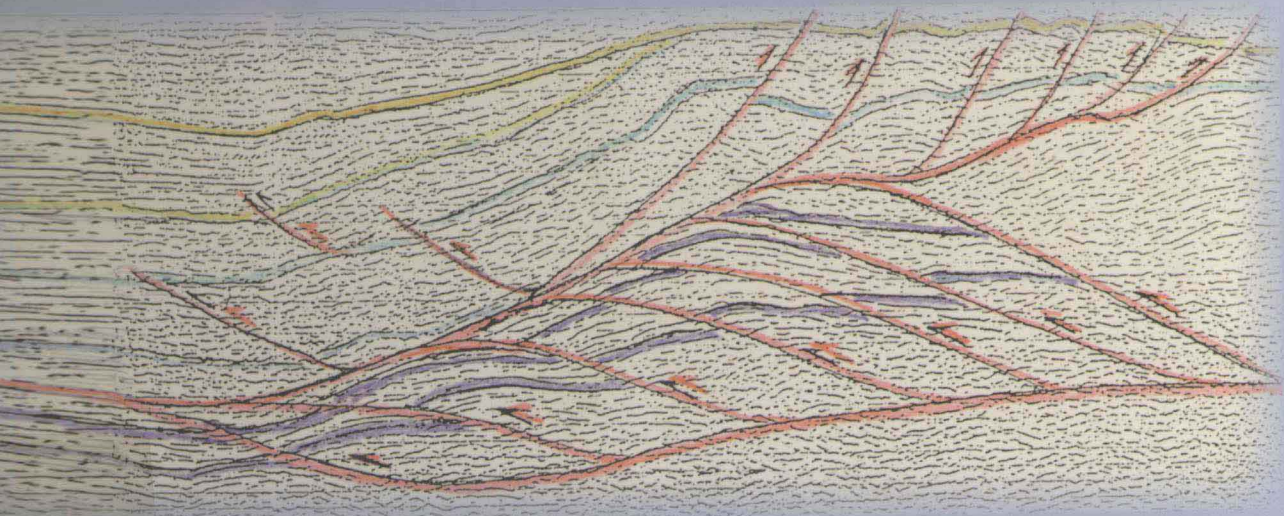


中国油气盆地 构造演化与油气聚集

TECTONIC EVOLUTION AND HYDROCARBON
ACCUMULATION OF PETROLIFEROUS
BASINS IN CHINA

吴奇之 王同和 等著

Wu Qizhi Wang Tonghe et al.



石油工业出版社

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中国油气盆地构造演化 与油气聚集

吴奇之 王同和 李明杰 杨德垠 著

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内 容 提 要

本书利用建国以来，特别是近年来大量地质、地球物理和钻井等新的油气勘探资料，从活动论、阶段论和转化论角度，结合其它石油构造新观点、新理论，较全面、系统地阐述了中国引张-裂谷、挤压-前陆、走滑-拉分和稳定克拉通四种不同类型盆地的结构特点、构造特征、叠置关系、演化过程和形成机制及其与油气聚集和分布规律的关系。

本书在东、西部盆地类型历史分析与应力分析、造山链滞后伸展作用和郯庐、红河、阿尔金巨型走滑断裂带转换对盆地形成和反转变形分析等方面有许多新的认识，尤其是对发掘被隐藏的油气资源具有指导意义。因而本书不仅对于众多地学理论研究人员，而且对于生产实践工作者均有重要的参考价值。

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序

经过建国 40 余年大规模油气资源的勘探与开发,已发现亿吨级大油气田 30 余个,年产原油 1.5 亿吨,从而跨进世界石油大国的行列;同时也积累了极其丰富的实际地质资料,特别是勘探新方法、新技术的应用正在不断地更新已有的认识。因而,需要全面系统的总结和理论认识上的进一步提高。尤其是以活动论为核心的新构造观对中国油气富集规律、油藏形成特点的地质构造背景的研究,不仅对深化老油区的认识和开拓油气新地区、新领域、新类型和深层的勘探具有指导作用,而且将对中国大陆构造变形的理论研究提供新资料和新思路。

本书重点追溯了中国大陆地壳漫长、复杂的构造演化历史,建立了我国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,包括不同历史时期所形成的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移位分布。这对于深化盆地的形成与发展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,特别是跨世代的油气运移、聚集与分布规律,都具有十分重要的实际意义。

从对基础资料的分析出发,作者从板块运动学角度和阶段论观点,对中国东、中、西部的构造差异进行归纳总结,认为东、西部在不同历史时期均经历过复杂、多期交替挤压、拉张过程。郯庐、红河和阿尔金三大走滑断裂带在变形、变位过程中扮演了重要角色;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。特别强调了在早、中燕山期,中国大陆构造地貌表现为东高西低和东压西张,而现今的东张西压和东低西高三大台阶是喜山期变形的结果;并提出大兴安岭以西也存在象鄂尔多斯和四川大型北北东向早、中侏罗世盆地等。

作者还对造山带与盆地关系、造山链滞后伸展作用所形成的盆地及其含油气性、韧性剪切变形、流体作用和动态部分熔融等盆地形成的机制进行了描述。着墨不多,但体现了盆地构造研究的新进展和发展趋势。

根据主要目的层的盆地性质,可以划分为裂谷盆地、前陆盆地、走滑拉分盆地和克拉通盆地四大类。适度引进了当代石油构造学的一些新概念和新模式,对其形成机制进行了有益的探讨,并将不同时代的原型盆地在纵向上划分为重叠式、交叉式、披覆式、镶嵌式和掩覆式五种叠置类型,认为披覆式和掩覆式盆地对油气形成、聚集与保存极为有利,这对油气勘探具有指导意义。

以大量实际资料为依据,结合区域构造背景、构造成因和油气赋存状态,划分了伸展、挤压、走滑三大类 8 个亚类 40 余种局部构造样式,指出了不同性质的盆地及其不同构造部位有着不同的有利于油气聚集的构造样式。

在综合中国油气盆地的构造类型、叠置关系、演化过程和形成机制以及地温场特征之后,认为具有高地温场的东部拉张区以产油为主,中地温场的中部稳定区以产气为主,而低地温场的西部挤压区则油气兼而有之。并具体指出了西北地区的侏罗系、三叠系、二叠系,大兴安岭以西的中、下侏罗统,华北的古生界,南方的前陆盆地和藏北的残余盆地及海域的新生代盆地等是重要的油气勘探领域或地区,这对今后油气勘探具有重要的指导意义。

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,对中国含油气

盆地的构造分析研究具有较高水平。不仅对含油气盆地构造研究具有指导意义和实际价值，对国内外大地构造变形研究，也是一部不可多得的珍贵参考资料。为此，我谨向辛勤劳动的编者致以衷心祝贺。

马书恒
1996年10月10日

Preface

After forty – year large – scale exploration and development for oil – gas resource since the foundation of the people’ s republic of China, more than thirty hundred-million-tons grade large oil – gas fields have been found, annual production of crude oil reaches 1. 5 hundred million tons, thereby we have stepped into the ranks of major oil production contries in the world. We have, moreover, accumulated a lot of practical geological data, especially the new exploration methods and technologies. Therefore on the basis of extensive practice, it needs systematic summation and further increase on theoretical knowledge. Especially on the basis of the new tectonic view, it is used to analyse the geological tectonic setting of the hydrocarbon accumulation law and oil reservoir formation of China. It will not only be of actual value to deepening the cognition of mature old oil province and developing immature oil areas, new fields, new types and new exploration depth, also make a new contribution to providing new data to the theoretical study of the continental tectonic deformation of China.

The emphasis of this book is on the analysis of the long, complicate tectonic evolution history of Chinese continental crust, the determination of the foundmental tectonic scenarios of different historic stages and sedimentary framework of different property basins and their distribution (including the characteristics of the structure styles and structure features formed in different historic periods) and their interrelation and development on time, mutual overlap and transposition distribution on space. This will be of momentous current significance to deepening the basic law of the basin’ s formation and development and the geodynamic setting of continental crustal deformation, and the law of oil – gas enrichment and distribution, particularly the law of the trans oil – gas generation, migration, accumulation and distribution.

Proceed from the analysis to the basic data, the author from the view of plate kinematics and stage theory point, deeply sums up the tectonic difference among the East, Middle, West China, then concludes the East and West both underwent complex, multiperiodic alternately compression and extension process. The three strike – slip fault zones of Tanlu, Honghe and Altun played an important role during the process of the deformation and dislocation. Present basins are the structure dynamic development association of multi – perodic, polygenetic, muti – level gliding – nappe and nappe. Especially in early Yanshan period, Chinese continental tectonic landform presented as high in the East and low in the West, compression in the East and tension in the West, while now it transformed into tension in the East compression in the West, three steps of low in East high in West, this is the products of Himalayan period deformation. In the West to Daxingan Ling also exists large north – east – north trend early – mid Jurassic basins like that of Sichuan and so on.

The editor also discribed the basin’ s formation mechanism owing to the relation between orogenic belt and basins, basins formed of orogenic chains lagging behind extension and its hydrocarbon – bearing property, and mechanism of ductile shear deformation, fluidization and dynamic local liquation, and so on, although sketchily painted, embodies the new progress and developing tendency of the basin structure study.

According to the characteristic of oil – producing layers basins are divided into four types, i. e. , rift basin, foreland basin, strike – slip pull – apart basin and cratonic basin. This book moderately introduced some new concepts and patterns of contemporary petroleum tectonics, profitably probed into their formation mechanism, and divided the prototype basins of different time into five types of superposition, intersection, drape, mosaic and overriding on vertical direction, and believes drape – type and overriding – type basins are very favourable for gas – oil generation, accumulation and preservation, this will be of directing significance to the oil – gas exploration.

On the basis of a vast amount of practical data, combined with regional tectonic setting, structure genesis and hydrocarbon host state, they were divided into over forty local tectonic styles of eight sub-sorts belonging to extension, compression and strike – slip, three types. It is pointed out that different plate tectonic locations have different tectonic styles favourable for oil – gas accumulation.

After synthesizing the structure types, overriding relations, evolution process and formation mechanism and geotemperature field features of Chinese oil – gas basins it is thought that the major oil – producing is in eastern extension area with high geotemperature field and gas – producing ones in middle stable area with mid – geotemperature field, while western compression area with low geotemperature field has both oil and gas producing formations at the same time. And it is concretely demonstrated that the Jurassic, Permian, Triassic system of North – West area, middle – lower Jurassic series of west to Daxingan Ling, Paleozoic group of North China, foreland basins in South and relic sea basins and Cenozoic basins in North ? Tibet, and so on, are all important oil – gas explorationn sphere, this is very important for guiding oil – gas exploration.

In short, this book is the crystallization of production integrating with scientific research. It has abundant practical data and high reliability, its analysis and study to the Chinese petroliferous basins is on a higher level. It not only has actual and directing value, also is a rare precious reference material for studying geotectonics deformation at home and abroad. At the end, I sincerely extent my cordial greetings to the industrious compiler.

Ma Xingyuan

1996.10.10

前 言

建国 40 多年来, 经过石油地质工作者的艰苦奋斗, 石油工业迅速发展, 年产原油 1.5 亿吨, 从而跨进世界石油大国的行列。由于这些产量主要集中于 30 多个亿吨级储量的大油气田中。因此, 深入总结大油气田的勘探经验, 研究其形成条件和地质规律, 不仅对于指导新区勘探和深化老区的认识具有重要意义, 而且具有十分重要的学术价值。鉴于油气大规模勘探实践积累的丰富资料, 中国石油天然气总公司决定, 在“八五”期间系统总结编写“中国陆相大油气田地质规律和勘探经验”丛书, 作为石油勘探战线建国以来一项重要的勘探、科研成果, 以供各级领导、科技人员和院校师生参考使用, 进而深化中国石油地质理论, 促进油气勘探与开发事业向纵深发展, 以保证我国在 2000 年前后经济发展目标的实现对油气资源的需要。“中国陆相大油气田地质规律和勘探经验”课题, 就是在这种情况下立项而开展工作的。

本书原课题为“中国陆相含油气盆地形成的地质基础”, 它是“中国陆相大油气田地质规律和勘探经验”总论中的组成部分。内容包括: ①中国大陆构造演化和东、中、西部构造差异, 初稿由王同和编写; ②中国陆相含油气盆地构造类型及形成机制, 初稿由李明杰编写; ③构造样式、特征及其含油气性, 初稿由杨德垠编写; ④中国油气区划及勘探前景展望, 由吴奇之和王同和共同讨论完成。于 1995 年 6 月, 初稿完成后由王同和统一修改、补充、汇总成稿, 并成为本书的基础资料。

本书编写力求做到定性、定时和定量。定性就是从地球动力学角度和活动论观点阐述盆地类型、演化过程和形成机制; 定时即是从板块运动学和阶段论角度来研究盆地的性质和叠置关系; 定量则是从构造几何学角度和转化论观点来分析盆地的沉积格架、构造样式及其反转特征。

本书适度引进了当代石油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。研究含油气盆地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藏的油气领域。

本书尽量避免与石油构造地质学内容上的重复和突出中国石油构造特色, 因而引用了大量国内新的油气勘探资料。

本书是在吴奇之总地质师组织、指导下, 在原来初稿的基础上, 于 1996 年 7 月—1997 年 6 月, 由王同和进一步统一拓展、深化编写而成。

本书共九章, 编写分工为: 前言、结论, 第一章~第六章和第七章、第八章的部分内容由王同和编写, 第七章、第八章分别由李明杰、杨德垠编写, 第九章由吴奇之、王同和共同讨论而成文。最后由王同和统一编改、修定, 由吴奇之审定。

在本书编写过程中, 得到中国石油天然气总公司石油地球物探勘探局地质研究院领导高岩、刘志芳全力支持和对图件、文稿进行审查、指导, 承蒙马杏垣教授审阅书稿并作序, 谢晓安、张振生、高增海高级工程师审阅初稿, 提出宝贵修改意见。

本书引用了各油田、中国石油天然气总公司石油地球物探勘探局以及石油院校等单位资

料，除在本书具体注明外，在此一并表示衷心致谢。

先后参加这项工作的还有黄丽峰、姜军、刘晓芬等，图件绘制多由何晓南完成。

此书只是一次尝试性、阶段性的总结。限于水平，缺点、错误在所难免，敬希读者批评、指正。

编者

1996年10月

Foreword

During the past 40 years since the construction of our new country, the petroleum industry has been developed rapidly by the hard work of petroleum geological workers. Now our country can yield 150 million tons of crude oil per year and has become one of the most productive countries of petroleum in the world. Since the oil is mainly focused on more than 30 large oil – gas fields with a 100 million tons of reserves, it is not only very important for the directing of the new fields exploration, and the deeping of the old fields, but also has very important academic value if we can summarize the exploration experience of the large oil – gas fields and study their formation condition and geological rule. In view of the rich data accumulated by the practice of the oil – gas exploration, China National Petroleum Corporation (CNPC) determines to compile systematically the series books of “Geological Rule and Exploration Experience of Large Nonmarine Oil – gas Fields in China” During the eighth – five – year plan. The CNPC hopes that these books can become the important exploration and research achievements of the petroleum exploration workers since the construction of our new country, and they can also be refered to by the leaders, researchers and universities & colleges. It also hopes that the petroleum geology theory of China can be deeped, and the development of oil – gas exploration and production can be promoted. Thus, it can be assured that the hydrocarbon resources can meet the need of the realization of the economic development aim around 2000. The program “Geological Rule and Exploration Experience of Nonmarine Large Oil – gas Fields in China” is determined and started to work under this situation.

This book is finished by deeping and extending the program “Outline of Tectonic Structure of Hydrocarbon – bearing Area in China” which is part of the general topic of “Geological Rule and Exploration Experience of Nonmarine Large Oil – gas Fields in China”. It includes 1) tectonic evolution of China continent and tectonic difference of East, Middle and West China (based on Wang Tonghe), 2) Style of hydrocarbon – bearing basins and division of hydrocarbon area in China (based on Li Mingjie); 3) Tectonic pattern, Characteristics and hydrocarbon – bearing feature in the hydrocarbon – bearing area (based on Yang Deyin); 4) Future of exploration of hydrocarbon resources (based on Wu Qizhi and Wang Tonghe).

We compile this book based on a qualitative, timing and quantitative criterion. The qualitative criterion is to discuss the division of basin style, evolution and formation mechanism according to geodynamics and mobil theory. The timing criterion is to study the feature and overriding relation of basins according to plate tectonics and periodical theory. The quantitative criterion is to analyze the sedimentary sketch, tectonic pattern and the reverse feature of basins according to tectonic geometry and invert theory.

The book introduces appropriately some new method, concept, model and theory from the recent research of petroleum structure and try to integrate geology with geophysics, orogenic zone with basin, shallow structure with deep one, regional tectonics with local one, static with dynamic, formation with deformation, and construction with reformation. The book is also try to study the formation and evolution of hydrocarbon – bearing basins and discuss the tectonic setting and the distribution rule of the for-

mation and congregation of oil – gas so that we can discover the oil – gas area which is buried and hidden and provide new are in the exploration of oil and gas.

General Geologist Wu Qizhi is in charge of the organization and leadership of this book and Liu Zhifang has attended the discussion and leadership for many times. Wang Tonghe works out the plot and writes the guideline.

Nine chapters are divided and they are written respectively by: Wang Tonghe (Introduction, Conclusion, Chapters 1 – 6, and part of chapter 8), Li Mingjie, Yang Defing and Wu Qizhi (Chapter 7, 8 and the first two parts of chapter 9). Finally, Wang Tonghe writes and compiles the whole book and Wu Qizhi examines and approves it.

While compiling this book, leaders of Institute of Geology, Geophysical Exploration Bureau have supported us greatly and examined our figures and manuscript. Prof. Ma Xingyuan checks and approves the manuscript and then writes the Preface. Senior Engineers Xie Xiaolan, Zhang Zhensheng and Gao Zenghai have examined the first draft and given their suggests of revision.

This book has quoted many data from oil fields, petroleum geological exploration bureaus and petroleum universities & colleges. We thanks for their data except that we have marked them in the book.

Huang Shuofeng, Jiang Jun, Lin Xiaofang have also attended the work. He Xiaonai finished most of the figures.

This book is only a tentative and periodical summary of the work. please criticize and correct them if there are some shortcoming and errors.

——Editors

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第一章 石油构造研究新进展

石油构造学与其它学科一样，随着科学技术的发展，新方法、新技术的应用，研究领域明显扩大和日益深化。学科间彼此渗透又互相综合，正朝着立体化、量化、动态化、综合化和模拟仿真的方向发展。石油构造领域的信息量与日俱增，新思维、新概念、新理论层出不穷。如地体说、构造流变学、构造相变学、构造物理学、构造地热学、系统构造学等横断科学悄然兴起，曾给石油构造学带来了活力。特别是与板内变形相关的“楔块构造”、“层圈构造”新概念的产生，对于研究板内各种样式的构造变形，例如推覆构造、伸展构造、走滑扭动构造和旋转构造（包括块体绕水平轴和垂直轴的旋转）及与之相配套的前陆盆地、拉张盆地和拉分盆地等的成因机制均产生了深刻影响。特别是拉张盆地的伸展模式（纯剪模式、单剪模式和复合剪切模式），前陆盆地挠曲沉降机制（岩石圈粘弹性回跳模式）和走滑拉分盆地的拉分机制的提出，大大深化了盆地形成与演化的认识。对于油气圈闭构造，如与挤压收缩有关的断展褶皱、断弯褶皱、断滑褶皱、双重构造、冲起构造、反转构造和与引张有关的逆牵引构造、滑脱构造、断坡构造，以及与走滑有关的花状构造、传递构造、连锁断裂构造等新概念的产生亦给石油构造研究以巨大的推进，并给油气勘探活动带来繁荣。这些学科的发展、形成与完善及诸多新概念的提出，使石油构造学的研究内容和学科结构发生了重大转折与改观，也是当代石油地质科学研究的重大前缘领域和生长点。尤其是杂交、移植来的一些学科并用定量手段以解决石油构造问题，虽然还是个开头，但却展示出诱人的前景。

总的来看，石油构造研究日趋由定性向定时和定量方面发展。定性就是从地球动力学角度和活动论观点进行盆地类型划分，确定盆地的演化机制；定时即是从板块运动学角度和阶段论来研究盆地演化序列和叠置关系；定量则是从构造几何学角度和转化论观点来研究盆地的沉积格架和构造样式及其反转特征。下面以与油气勘探密切相关的几个石油构造问题予以简要介绍。

第一节 地体说

地体说亦称增生地体说，全名为“构造地层地体”说。它是由美国、加拿大两国地质学家 Janes, Monger 和 Howell 长期在西部海岸带的科迪勒拉山系从事地质调查提出的，并把那里由一系列以断层为边界、地质特征完全不同、各自有其独立发展史的不规则的集合体称为地体。它是继板块构造理论之后而发展起来的一门新的探索地壳演化规律的大地构造理论。这不仅用来解释环太平洋地区的大地构造演化，而且也为大陆复杂多样的地质构造研究提供了新的思路和方法。地体构造理论一经出现，便显示出强大的生命力。在短短的十年中，发表了大量论文和专著，使之逐步得以补充与日臻完善，并取得了以下几方面的新进展。

(1) 地体应用的地区明显扩大。以往仅限于北美等地，近年来迅速扩大到所有大陆边缘，既有被动边缘也有活动边缘。地体可出现在洋—陆作用过程中，还出现于陆—陆碰撞、洋—弧或弧—弧作用过程中，转换作用和走滑剪切移动亦可引起地体增生，说明地体增生可以是多种运动形式（图 1-1），如俯冲式和停靠式等出现在不同区域和多种多样的构造环境中（图 1-2）。

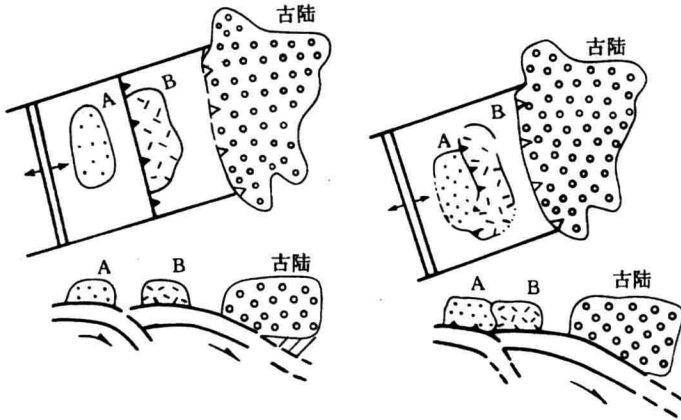


图 1-1 示拼合增生作用（据水涛，1994）
上：平面图；下：剖面图

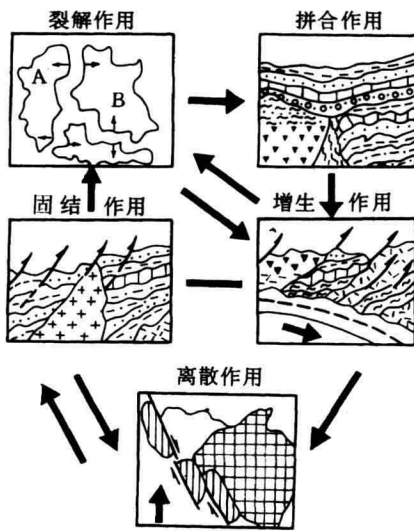


图 1-2 地体运动作用过程及复杂的相互关系
（据水涛，1994）

(2) 地体适用的时代范围明显扩大，不再限于中、新生代。随着地体研究的深入和广泛开展，已发现古老的地体存在，如在北美前寒武系中已划出 34 个古地体 (Leitck, 1989)，在中国东南地区亦存在有元古代和古生代地体，并再造了它们的漂移和联合的历史 (郭令智, 1984, 1989)，所以地体的发生、漂移、增生机制在古生代乃至元古代即已存在，这与板块构造存在的研究成果一致。

(3) 在活动大陆边缘，尤其是岛弧带，大陆生长主要通过地体增生来实现的。鉴于地体主要依靠增生而就位，故地体不出现在大陆内部，只能位于不同时代的大陆边缘。这是研究地体时应予以重视的问题。不过，增生期后的聚敛作用，可以使地缝合线以逆冲断裂作用或水平位移滑动作用的形式再度活化，并造成地体强烈皱缩和前陆的形变作用，以及原地体再发生裂解、离散作用使其碎块再与别的地体碰撞。有时还因板间力学性质的转变使地体在迁移过程中发生旋转（图 1-3）。

(4) 地体具有时代意义，在划分地体时，应注意两个地体在该时期内，处于互相隔离