地球科学

中国岩石圈三维结构丛书之二

Series of Monographs on the Three-dimensional Structure of Lithosphere in China

中国西部岩石圈三维结构及演化

肖序常 姜枚 等 著

3D LITHOSPHERE

地质出版社

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内 容 提 要

本书以中国西部历年来地质-地球物理研究成果资料为基础，通过对资料相对丰富的剖面的重点分析研究，提出了西北盆山-青藏高原岩石圈三维结构单元的划分方案及三维岩石圈构造演化模式。本书可供有关地质科研、生产和教学人员参考。

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中国岩石圈三维结构丛书
编辑委员会

中国岩石圈三维结构丛书

Series of Monographs on the Three-dimensional Structure of Lithosphere in China

1 中国岩石圈三维结构
The Three-dimensional Structure of Lithosphere in China

2 中国西部岩石圈三维结构及演化
The Three-dimensional Structure of Lithosphere and its Evolution in Western Part of China

3 中国兴蒙-吉黑地区岩石圈三维结构及演化
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The Composition and Evolution of Lithosphere in China Continent

序

地球是一个由多个圈层组成的复杂球体。岩石圈是地球浅部的刚性圈层，由地壳和地幔盖层组成。

地球科学的根本任务在于研究和认识地球，并利用这种认识去保障人类所需的自然资源的供给和人类居住环境的优化。岩石圈是近年来地球科学中发展起来的一个新的研究方向和前沿性研究课题。人们在生产和科学实践中逐渐认识到，研究岩石圈，认识岩石圈，不断充实岩石圈的科学知识，对于探讨地质规律、解析矿产成因、评估地质环境质量和地质灾害形成机理，以及洞察大陆演化的动力学过程等，都具有重要的意义。

正是由于以上的原因，自20世纪50年代以来，为了从整体上研究和认识地球，国际地学组织先后实施了“国际地球物理年”等国际合作研究计划。特别是从20世纪80年代开始，为了阐明岩石圈物质组成、结构构造、演化及动力学机制，国际组织实施了“国际岩石圈动力学和演化”及“国际岩石圈-生物圈计划”等大型国际合作研究计划；美国、加拿大、欧洲一些国家也实施了大规模的岩石圈研究计划。用地质、地球物理、地球化学相结合的方法，开展了全球地学断面以及重要造山带、地质区及沉积盆地岩石圈结构构造及深部作用过程的调查研究，取得了诸多创新性研究成果，深化了对岩石圈性质、成因的认识，为建立地球系统科学的知识体系奠定了良好基础。

几十年来，我国开展了规模宏大的地质调查、地球物理探测、地球化学勘查及岩石圈地质研究工作，中、小比例尺区域地质调查和航空磁测已覆盖全国陆地及毗邻海域的部分地区；以爆破地震为主的地球物理测深剖面已完成约50000 km，并完成了大量其他方法的地球物理探测工作。20世纪80年代以来，我国参与了国际岩石圈研究计划，进行了11条地学断面以及碰撞造山带超高压变质作用和动力学、沉积盆地成因及全球地震活动性等的研究，并在苏北实施了深度达5100余米的大陆科学钻探工程。多年来的地质调查研究积累了极为丰富的数据和资料。

为了系统总结我国深部地质、地球物理调查及岩石圈研究成果，国土资源部于2000年制定并实施了“中国岩石圈三维结构”专项研究计划。该计划包括3个重点研究项目：中国岩石圈三维结构数据库、重点区段岩石圈三维结构特征、中国大陆岩石圈三维结构及其演化与动力学。研究的任务和总目标是：以现代地学理论为指导，以新技术方法为手段，对已积累的岩石圈数据、资料进行多学科综合研究，揭示中国岩石圈三维结构及演化规律，为国土资源规划、管理、保护和合理利用提供科学依据，为国家经济社会可持续发展规划提供科学基础，为创建地球系统科学理论开辟科学的突破口。

参加该专项研究和管理工作的包括来自中国地质科学院地质研究所、中国地质科学院矿产资源研究所、中国地质科学院机关、国土资源部国际合作与科技司、中国地质调查局、中国地质大学（北京）、中国地质大学（武汉）、吉林大学、成都理工大学、同济大学、中国地质调查局广州海洋地质调查局、中国石油化工集团上海石油规划设计研究院、

中国地质调查局天津地质矿产研究所、国土资源部信息中心和实物地质资料中心等 14 个单位 100 多位科研和科技管理专家。

在全体参研专家、学者们的辛勤劳作和精心研究下，圆满地完成了专项计划任务，达到了预期目标，各个项目和课题都在各自的研究领域取得了丰硕的科学成果。

“中国岩石圈三维结构数据库”是我国建立的第一个全国性的岩石圈结构数据库，它由 9 个原始数据库、3 个成果数据库和 2 个总库共 14 个子库组成。该数据库收录的数据量大，学科涵盖面广；数据库软件先进，管理系统灵活实用；并可通过互联网实现信息的国际交换与数据共享，将成为我国岩石圈探测研究成果信息化和数据共享的范例。

各重点区段课题均以地学断面资料为基础，开展了地质、地球物理、地球化学等多学科综合研究，总结了区段内造山带、盆地和克拉通等构造单元岩石圈结构特征及相互间的时空联系，初步建立了岩石圈三维结构可视化模型。通过研究深化了对中国岩石圈物质组成及结构构造的认识，在中国东部，岩石圈与软流圈之间显示分层不明显的过渡带的存在，岩石圈呈现明显的“上老下新”年龄结构。在青藏高原近南北向巨型航磁异常带部位，在岩石圈深部也发现更为明显的近南北向的构造带，显示了岩石圈表层与深部构造的极端不均一性。

在岩石圈数据库及重点区段岩石圈结构研究的基础上，围绕“中国大陆岩石圈三维结构及其演化与动力学”这一主题，开展了综合研究和成果的集成，汇集编制了表达中国岩石圈结构和演化的系列图件；划分了中国大陆及其邻近海域岩石圈构造单元和岩石圈构造类型，总结了各岩石圈构造单元基本特点；论证了中国岩石圈地球物理场及地球化学场特征；探究了中国岩石圈物质结构及化学结构；进行了岩石圈三维结构的数值模拟，探讨了中国岩石圈的演化及动力学过程。

为了充分展现专项研究的成果，为有关部门和地学界奉献尽可能多的有关中国岩石圈的信息，除提交“中国岩石圈三维结构数据库”和“中国岩石圈三维结构特征图集”外，我们根据合同书的要求，在研究报告基础上编著了《中国岩石圈三维结构丛书》。这套丛书包括一部全国性论著和 8 部区域性专著，分别论述了全国和 6 个区段的岩石圈构造单元及秦岭、大别-苏鲁两个造山带岩石圈三维结构及其演化特征。

科研实践和科学成果说明，国土资源部实施“中国岩石圈三维结构”专项研究计划是一个有远见卓识之举。

通过专项研究计划的实施，建立了具有现代科学技术水平的“中国岩石圈三维结构数据库”，对我国积累的海量地质、地球物理、地球化学调查研究资料和数据进行了系统汇集；对一些面临散失和行将毁损的珍贵资料进行了抢救性收集、整理和转存；对大部分地球物理剖面进行了资料的再处理、再解释，挖掘出了更多地质信息。

通过专项研究计划的实施，取得了一批高水平的和创新性的科学成果，缩短了在岩石圈研究上与发达国家的差距。对中国岩石圈进行了地质、地球物理、地球化学相结合的综合研究，划分了中国岩石圈构造单元和类型，总结了中国岩石圈的若干特点和演化规律，揭示出若干新的事实和新的现象，深化了对中国岩石圈三维结构及其演化过程的认识，为解决资源、环境勘查、评价的一些重大科学问题奠定了基础。

通过专项研究计划的实施，推动了科研单位、高等院校和地质勘查单位的结合，实现了岩石圈研究的强强联合，巩固和发展了一些岩石圈研究基地和科研群体，培养出一批年

轻的岩石圈研究人才，打造出一支老中青相结合的、水平较高的岩石圈研究队伍，为我国今后较大规模的岩石圈研究提供了某些方面的组织和人才保障。

通过专项研究计划的实施，不但解决或深化了一批岩石圈研究中的重大科学技术问题，而且在岩石圈物质组成及结构构造上发现若干奇异的新现象，揭露出一批有待进一步深入研究的科学问题。同时，积累了一些岩石圈研究的经验。这些科学问题和经验可供日后岩石圈研究者借鉴。

这一专项研究计划的实施和成功，是与全体科技人员的辛勤劳作和刻苦钻研分不开的，是与上级各部门的领导的关怀和指导分不开的。同时，也是与各协作单位的支持和协同分不开的。这里需要特别指出的是，国土资源部国际合作与科技司和黄宗理司长、崔岩副司长、白星碧副处长，中国地质调查局和叶天竺原局长、孟宪来局长、张洪涛副局长、彭齐鸣主任，中国地质科学院及张彦英院长、董树文副院长，中国地质科学院地质研究所及许志琴前所长、汪东波所长、耿元生副所长等，自始至终给予该专项计划极大的关注指导和鼎力支持，对计划的顺利实施发挥了重要作用。在这里向支持该专项计划的各级领导部门、各协作单位以及有关领导和专家、学者表示衷心的感谢。

这套丛书连同“中国岩石圈三维结构数据库”和“中国岩石圈三维结构特征图集”，集中反映了“中国岩石圈三维结构”专项研究计划所取得的研究成果。我们期望这些成果能够对发展岩石圈的有关理论和实际应用方面发挥较大作用，对深入研究中国岩石圈结构构造及其演化作出较大贡献。我们真心诚意地期望地学界同仁们的批评指正。

李廷栋

2005 年 3 月

前　言

为了揭示中国岩石圈三维结构特征及其演化规律，深化对中国大陆形成、演化及大陆动力学的认识，查明岩石圈三维结构特征与矿产资源（含能源）形成、分布以及与地质灾害成因机理之间的内在联系，从而为国土资源规划与开发利用、为国民经济可持续发展提供深部地质科学依据，为地球科学的理论创新和发展作出贡献，国土资源部将“中国岩石圈三维结构”研究列入了“十五”期间的重点科技专项计划。

该专项计划由中国地质科学院地质研究所负责，中国地质大学、吉林大学、成都理工大学、广州海洋地质调查局和上海石油规划设计研究院等单位参加。专项计划包括3个项目、6个区段课题。

项目Ⅰ，建立中国岩石圈三维结构数据库。包括网络数据库、深地震反射与宽频地震数据库、大地电磁测深数据库、大地热流测量数据库等14个子库。由中国地质科学院地质研究所负责，吉林大学、同济大学等参加。

项目Ⅱ，6个地区（区段）的岩石圈三维结构研究。包括：

（1）青藏高原-西北盆山岩石圈三维结构研究。中国地质科学院地质研究所承担，中国地质科学院矿产资源研究所参加。

（2）兴蒙-吉黑地区岩石圈三维结构研究。吉林大学（地球科学学院）承担。

（3）华北地区岩石圈三维结构研究。中国地质大学（北京）承担。

（4）东秦岭-大别-苏鲁地区岩石圈三维结构研究。中国地质科学院地质研究所和中国地质大学（武汉）承担。

（5）华南地区（含东海）岩石圈三维结构研究。成都理工大学负责，天津地质矿产研究所和中国地质大学（北京）参加。其中东海海域岩石圈三维结构研究，由上海石油规划设计研究院承担。

（6）南海海域岩石圈三维结构研究。广州海洋地质调查局承担。

项目Ⅲ，中国大陆岩石圈三维结构及其演化和编图。由专项计划专家组负责，各项目、课题组的有关人员参加。

上述3个项目的实施计划，分别为：

项目Ⅰ，2000年9月—2005年12月

项目Ⅱ，2000年9月—2004年6月

项目Ⅲ，2004年6月—2006年7月

为了确保上述专项计划的顺利实施，达到预期标准和实现预期目标，在国土资源部国际合作与科技司的领导下成立了专项计划专家组。专家组成员有：李廷栋（组长）、袁学

诚、肖庆辉、黄宗理、叶天竺。部国际合作与科技司主管本项目专家为白星碧。由专家组负责专项计划实施过程中的全面技术指导、各阶段的计划落实与检查、组织召开各项技术业务会议和进行统一管理等工作，并直接承担项目Ⅲ的综合研究任务。

为了加强专项计划实施过程中的项目管理，在专家组领导下，在中国地质科学院地质研究所建立了专项计划办公室，成员有：耿树方（主任）、范本贤、郝美英和姚培毅。办公室承担专项计划的日常管理工作，协助专家组制定有关的统一技术标准，草拟各项文件，筹办各项会议及编写各项总结等等，以确保专项计划的顺利实施。

本专项计划建立的“中国岩石圈三维结构数据库”，以及专项计划各项研究成果构成的“中国岩石圈三维结构系列丛书”与相关“图集”，将为实行岩石圈信息资源共享，全面了解和认识中国大陆岩石圈三维结构特征，发展和创新地球科学理论，发挥重要作用；将为国土资源规划部署，矿产资源勘查、研究，地质环境与地质灾害评估等，提供深部地质资料依据。

“青藏高原-西北盆山岩石圈三维结构研究”属本专项项目Ⅱ下属的区段课题。根据部国际合作与科技司专项计划的精神，我们在中国西部的地质地球物理研究中收集了资料，处理了有关数据，编制了相应的图件；同时对资料相对多的剖面作了重点分析，在现有的并不全面的资料中删除了少数不可靠的成分。作者相信本课题在处理中所使用的资料是可靠的，希望这些结果对后续的工作提供方便。

本书由地质学研究和地球物理学研究两部分内容组成。各部分的主要工作任务、成果分述如下。

地质地球物理综合研究方面基本达到了专项提出的要求，完成了下列图件的编绘：

研究区地质地球物理研究程度图；

三维构造单元划分和构造单元边界断裂分布图；

区域重力 Δg 平面图；

区域航磁 ΔT 平面图；

亚东-格尔木，格尔木-额济纳旗；花石峡-阿勒泰；狮泉河-叶城；和田-库车-布尔津等数条剖面的地质地球物理综合图；

分布在本区范围内的若干区段的断裂构造图，花岗岩、火山岩分布图，地壳结构图，地震层析图等图件。

在上述工作的基础上提出了中国西北盆山-青藏高原岩石圈三维构造单元划分的方案，三维岩石圈构造演化的模式。所有这些成果都充分利用了地球物理的深部资料，采取深部和浅部资料相结合的研究方式，将结构与演化结合，将邻国资料与境内资料结合，将新资料与有效的老资料结合等原则。

在工作中突出了深部资料的作用，恰当地利用研究程度较高的剖面资料，分析了全区三维构造。

科研课题的研究对三维岩石圈研究的成果对于开发大西北的战略部署起着积极的作

用，对西部地区地质地球物理的进一步研究具有促进作用。在此课题的基础上已开始了西北地区的地震综合研究，这将对本区的现代构造活动和地震预报提供新的依据。

全书共分九章，撰写分工如下：第一章青藏高原岩石圈构造块体（或构造单元）划分的主要地质依据由崔军文、张晓卫撰写；第二章中国西北盆山地区岩石圈三维结构及其演化由刘训、王永撰写；第三章中国西部岩石圈结构构造演化简要综述由肖序常撰写；第四章中国西北盆山-青藏高原地区岩石圈电性结构研究由谭捍东撰写；第五章青藏高原三维地震层析反演由薛光琦、钱辉撰写；第六章中国西部三维岩石圈结构研究（爆破地震部分）由王有学、姜枚撰写；第七章中国西部布格重力异常特征和地壳密度结构由彭聪撰写；第八章中国西部岩石圈三维磁性结构研究由薛典军、姜枚等撰写；第九章中国西部岩石圈特征由姜枚、王有学等撰写。书稿由肖序常、姜枚统稿和修改。

本课题的研究及本书出版得到了国土资源部国际合作与科技司、中国地质调查局、中国地质科学院及相关单位领导、专家和同事的大力支持，在此一并致谢。

中国岩石圈三维结构专项计划办公室

与本书作者

2004 年 7 月 13 日

Foreword

The Earth is a complex multi-layered sphere, of which the lithosphere is the shallow rigid sphere made up of crust and the upper mantle.

The primary aim of geosciences is to study and recognize the earth, to guarantee the natural resources satisfy human needs and make human habitation comfort on the basis of these recognized rules. In current geosciences, the lithosphere is a newly-developed research subject. It is very important significance on the probing geological laws, analyzing mineral resource genesis, evaluating geological environment and catastrophes, apperceiving continental evolution to study lithosphere, recognize lithosphere, gradually extend the lithospheric data.

For above-mentioned reasons, since 1950s, in order to study and recognize completely the earth, the International Geoscience Organization have implemented some international cooperation research projects, such as "International Geophysical Year". Especially from 1980s on, to make out the lithospheric constitutes, texture and structure, evolution and dynamical mechanism, the International Geoscience Organization have implemented such large-scaled international cooperation research projects as "International Lithospheric Dynamic and Evolution Program" and "International Lithosphere-Biosphere Program". In addition, USA, Canada, some states In Europe have implemented some large-scaled lithospheric research projects. By using of combination of the geological, geophysical, geochemical methods, the research and survey on the lithospheric texture and structure and deep processes of the global geoscience transect, important orogenic belts, and the sedimentary basins have done, and many innovative research results have been obtained, which make the lithospheric property and genesis be deeply recognized. That becomes the good basis for establishing the systemic geosciences.

During several tens of years, in China, some magnificent geological survey, geophysical detection, geochemical prospecting, and lithospheric research have been accomplished. The mid-scaled, small-scaled regional geological survey and aeromagnetic survey have covered with the continent of all over the country and abut part sea area; about 50000 km geophysical detection sections by explosion seismic method have been finished, a great lot of geophysical detection sections by other methods been finished. Since 1980s, China have taken part in the international lithospheric research project, such as 11 global geoscience transect, ultra-high pressure metamorphism and dynamics in orogenic belts, genesis of sedimentary basin, seismic activity all over the earth have been carried out. Additionally, the 5100 m deep Continental Scientific Drilling Project has been performed. The geological survey of multi-year accumulates and enriches the documents and data about the earth.

To systemically review and summarize the deep geology, geophysical survey and lithospheric

studying result, the Ministry of Land and Resource (MLR) constituted and performed a specialized research project of "3-D Structure of China Lithosphere", which is composed of three emphasis research programs: Database on 3-D Structure of China Lithosphere, 3-D Structure of Lithosphere in Some Key Areas and Segments, 3-D Structure , Evolution and Dynamics of China Continental Lithosphere. The task and aim are: based on current geosciences theory, new method and technique, to comprehensively study the accumulative lithospheric data and documents by multi – knowledge, to make out 3-D structure and the evolution laws of China lithosphere, to supply scientific foundation for planning, managing, protecting and utilizing land & resource with reason, to supply scientific base for sustainable development of society and economy, to pioneer and breakthrough for establishing systemically geoscience theory.

There are 14 units that participate in the specialized research project as follows: Institute of Geology, CAGS, Institute of Mineral Resources, CAGS, Chinese Academy of Geological Sciences, International Cooperative and Technological Bureau, MLR, China Geology Survey, China University of Geosciences (Beijing), China University of Geosciences (Wuhan), Jilin University, Chengdu University of Technology, Tongji University, Guangzhou Marine Geology Survey, Shanghai Oil Institute of Planning and Devising, Sinopec, Tianjin Institute of Geological and Mineral Resources; Field geological data Center, Information Center of Land and Resources.

All the experts and scholars do their best effort to accomplish the task, and the plentiful and substantial results have been acquired in each study field.

The Database of 3-D Structure of China Lithosphere, the first one established all over country, is composed of 9 primary databases, 3 result databases, 2 total databases, 14 sub-databases. The database has the following characteristics: large data volume, wide knowledge, advanced database software, agile and applied management system. In addition, the data may be shared and transferred on line, which will be the successful example of the lithosphere research of our country.

Based on the data of global geoscience transect, the subject group of each key area and segment has performed the comprehensive research on geology, geophysics, and geochemistry, and summarized the temporal-spatial relationship of structural characteristics of orogenic belt, sedimentary basin, craton, finally, basically established the visual model of the 3-D lithosphere structure. The above-mentioned study makes us more deeply recognize the lithospheric constitutes and structural feature. In east China, between lithosphere and asthenosphere there is a transitional zone with unconspicuous layer. The lithosphere shows the obvious age feature of upper-older and lower-younger. In the nearly NS-direction aeromagnetic anomaly area of Qinghai-Tibet plateau, to the deep section of lithosphere, the nearly NS-direction structural belt is found, which shows extreme inhomogeneity between the surface and deep section of lithosphere.

On the basis of the lithospheric database and the study of lithospheric structure, focusing on the subject of "Dynamics of 3-D structure and evolution of China continental lithosphere", the comprehensive research and result integration have been preformed——a series of maps showing 3-D structure and evolution of China lithosphere have been compiled; lithospheric structural unit

and structural type of China continent and about sea area have been divided; basic characteristics of every lithospheric structural unit have been summarized; geophysical and geochemical fields of China lithosphere have been discussed; substance and chemical structure of China lithosphere have been studied; numerical modeling of 3-D structure of lithosphere has been done; evolution and dynamical process of China lithosphere have been discussed.

For adequately displaying specialized research result, and supplying the information about China lithosphere for related sectors and geological field, we not only have submitted the database of 3-D structure of China lithosphere, the Atlas of 3-D Structural Characteristic of China lithosphere, but also compiled the series books of 3-D structure of China lithosphere based on the research report. These series books include a nationally work, and 8 regional monographs, in which the lithospheric structural units of all over country and six regional segments, 3-D structure and evolution of Qinling and Dabie-Sulu orogenic belts are studied.

The scientific research practice and results show that it is a very far-sight for MLR to carry out the specialized research project of "3-D Structure of China Lithosphere".

Through carrying out the specialized research project, the database of 3-D structure of China lithosphere with the current scientific and technique level has been established; the accumulated great number data about geology, geophysics, geochemistry have been collected; some data that may be lost or ruined have been collected, neatened, and displaced; most of the geophysical section data have been re-disposed and re-explained to make more geological information exhibit to us.

Through carrying out the specialized research project, a batch of high quality and innovative scientific results have been obtained to decrease the difference of lithosphere research with other developed states. Through systemically studying the geology, geophysics and geochemistry, the structural unit and type of China lithosphere have been divided, several characteristics and evolution laws of China lithosphere reviewed and summarized, several new facts and phenomena found, 3-D structure and evolution processes of China lithosphere deeply recognized. That will become the basis of some important scientific problems such as resources, environment.

Through carrying out the specialized research project, the scientific research units, universities and colleges, and geological survey institutes have been combined together, some research base of lithosphere and scientific research groups have been consolidated and developed, a batch of young research personnel have been trained. A research team, which is composed of high-leveled aged, mid-aged, and young personnel, must contribute to the large-scaled lithospheric research project in the future.

Through carrying out the specialized research project, a series of important science and technology problems have been solved and recognized more deeply, some new fantastic phenomena about substance constitutes and structure of lithosphere have been found, a batch of scientific problems need to be studied further in the future. In addition, we have accumulated some experiences on lithospheric research. In the future, these problems and experiences will be used for researchers to study the related subject.

The specialized research project being preformed successfully is related to the whole scientific personnel's effort, to every superior sector's guiding and attention, to every cooperative unit's supporting. It specially points out that Huang Zongli, Cui Yan, Bai Xingbi from Bureau of International Cooperative & Technology, MLR, Ye Tianzhu, Meng Xianlai, Zhang Hongtao and Peng Qiming from China Geology Survey, Zhang Yanying, Dong Shuwen from Chinese Academy of Geological Sciences, and Xu Zhiqin, Wang Dongbo, Geng Yuansheng from Institute of Geology, CAGS, have played a important role in the project performing. Here we honestly express our acknowledgments to them.

These series books with "Database of 3-D Structure of China Lithosphere" and "Atlas of 3-D Structural Characteristic of China Lithosphere" mainly reflect the research results of the specialized project. We expect that these results may play an important role in developing related theory and practice about lithosphere, and contribute to study structure and evolution of China lithosphere. In meantime, we honestly expect that the readers make suggestion to us.

Li Tingdong
March 2005

The Three-dimensional Structure of lithosphere and its Evolution in Western Part of China

(Abstract)

Part I Geological study on the three-dimensional structure of lithosphere and its evolution in western part of China

1. Geological evidences of the Tectonic units of Qinghai-Tibetan Plateau

The determination of macroscopic structural characteristics has great significance for the study of the uplift of the Qinghai-Tibet Plateau and its "dynamic model construction". The Qinghai-Tibet Plateau represents a gigantic "convergence-intracontinental subduction type" lithospheric block formed by amalgamation of six terranes of three plates (or old land), i. e. the North Kunlun-Altyn Tagh-Qilian terrane of the Tarim-Sino-Korean plate, the South Kunlun terrane and Hoh Xil-Bayan Har terrane of the South China-Southeastern Asian plate and the Qiangtang terrane, Gangdise terrane and Himalayan terrane of Gondwanaland, through multiple breakups, convergences and intracontinental subductions. It is separated from the Indus lithospheric block, Tarim-Alxa-Ordos lithospheric block and Yangtze lithospheric block by the south Qinghai-Tibet Plateau marginal junction zone, north Qinghai-Tibet Plateau marginal junction zone and east Qinghai-Tibet Plateau marginal junction zone respectively. According to the present-day dynamic characteristics, this gigantic lithospheric block (first-order tectonic unit) may be subdivided into four second-order tectonic units, namely, the Himalayan block, northern Tibet block, southern Qinghai block and Kunlun-Altyn Tagh-Qilian block, which are bounded by the Yarlung Zangbo junction zone, Xijir Ulan-Jinsha River junction zone and Central Kunlun junction zone successively. The four blocks may be further divided into several fault-bounded third-order tectonic units (terranes).

The various tectonic units making up the gigantic Qinghai-Tibet lithospheric block are situated in a unifying geodynamic system. This geodynamic system is generally manifested as follows: the Himalayan block and Kunlun-Altyn Tagh-Qilian block on the southern and northern sides of the Qinghai-Tibet lithospheric block are asymmetrically thrust toward and stacked on the cold and rigid Indus lithospheric block and Tarim-Alxa-Ordos lithospheric block respectively in the tectonic setting that the Indian plate is continuously and strongly subducted beneath the Eurasian plate and the hot Qinghai-Tibet lithospheric block with ductile rheological properties moves en bloc in a NNE direction. Beneath the northern Tibet block and southern Qinghai block in the interior of the

Qinghai-Tibet Plateau, large numbers of low-velocity bodies at depth upwell and propagate horizontally from west to east. In this tectonic setting, the former is superimposed by nearly N-S compression, forming a tectonic framework marked mainly by N-S-trending downfaulted zones and NW- and NE-trending conjugate strike-slip motions; whereas for the latter, except for the Songpan-Garzê terrane that shows south-vergent thrust stacking, the Hoh Xil-Bayan Har terrane is mainly manifested by sinistral strike-slip motion leading to successive eastward extrusion, so that the whole southern Qinghai block experiences thrust propagation toward the Yangtze block and spreading toward the Sanjiang tectonic zone. Therefore, with increasing rate of uplift with time, the plateau also propagates gradually toward the rigid blocks at its peripheries, i. e. the area of the plateau expands progressively. So the plateau boundaries have the nature of propagation. On the basis of the propagation mechanism, two types of dynamic boundary may be distinguished: strike-slip type propagation boundary and thrust type propagation boundary. The typical propagation boundary is located in the Altyn Tagh mountains on the northern margin of the Qinghai-Tibet Plateau and the Sanjiang area on the eastern margin of the plateau. The dynamic boundary on the southern margin of the plateau belongs to the typical thrust type propagation boundary, while the dynamic boundary in the Qilian and Longmen mountains has both the nature of thrust propagation and the nature of strike-slip propagation.

2. The three-dimensional structure and its evolution of the basin-ranges in Northwestern China

Based on the comprehensive analysis about the abundant data of this area, especially the data of some Geotransects, and some deep geophysical researches, we could get a series of considerations as follows:

(1) The tectonic units of lithosphere can be divided into several different areas, and the features of different units and their boundary faults be discussed.

(2) We suggested that the unhomogeneous is the major reason of tectonic movements. In this area, the structure, thickness and composition of crust an upper mantle are different. Under the function of press-force, that is mainly from south in this area, the basin-mountain geomorphic structure we see nowadays was formed.

(3) The formation of the structures in crust and lithosphere is the product in a long time of geological history. So, we couldn't discuss it away from their history. About this area, the unified continent was formed from Late Permian, then the tectonic regime transformed from plate tectonics to basin-mountain tectonic framework. After more than 200Ma, through several cycles from folded-uplifted to erosion-planation to depression and deposition, the basin-mountain tectonic framework was formed as we see in nowadays.

(4) As the main mountains, the development and formation of Tianshan displayed, that the continent of both sides collided since Late Permian. But the absence of magmatic activities of Meso-Cenozoic, combined with other tectonic and structure types and possibility of southern subduction of Junggar plate, suggest that there is magnificent difference in the formation mechanism between Tianshan and Himalaya mountains.