实验构造地质学及其应用

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内 容 简 介

本书是作者30余年工作之总结，也是我国实验构造地质学的一个总结。内容包括实验构造地质学的研究方法、构造模拟实验相似条件和相似材料的选择、各种基础构造形式的形成机制研究及各种尺度的典型构造现象分析、模拟研究和构造模拟实验的应用初探，并对该学科的发展做了展望。书中着重对各种典型地质构造现象形成过程进行模拟研究，并结合野外实际构造现象做对比分析。书末还附有40个各种典型地质构造野外观察和室内模拟实验研究的彩色图版。

本书可供广大从事科研、生产、教学等地质工作者参考，也可作为地质、石油、冶金等专业的高等院校高年级学生和研究生的教学、学习参考用书。

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Experimental Structural Geology and Its Application

Zhong Jiayou

Science Press, Beijing, China
1998

序　一

岩层或岩体受外来各种应力的影响而发生各种变形，结果出现各式各样的地质构造，后者在野外观察中随时可以遇到，也在各种教科书中有系统的记载。这些构造是怎样产生的呢？本世纪初以来，西欧、北美、乃至前苏联和日本，都有人利用室内模拟试验来观察、研究和阐明某些地质构造的发生和发展的原因，这种工作对了解自然界中地质构造乃至大地构造的形成及其格局有很大帮助。

在我国，李四光教授从30年代起，即建立了试验构造地质室，进行各种模拟试验，获得了很多有趣的成果。继李四光之后，张文佑教授把这项工作向前推进了一大步，其间钟嘉猷同志，作为张教授的得力助手，曾长期担任这种实际工作，熟练地掌握了各种试验方法，得到各种不同的成果，并结合自己的野外观察，对中国境内的某些地质构造作出其应力场的推断，获得可喜的成功，近年来他在讲授试验构造地质学的同时，阅读国外同行的各种书刊、杂志，予以消化吸收，写成《实验构造地质学及其应用》一书，全书30多万字，共分14章，并附插图百余幅，图版40幅。洋洋大观，丰富多彩。这在我国确是第一次开拓性工作，对广大地质工作者将有很大的启发。为此，我推荐此书，并为之序。

黄汲清

Foreword I

Under the effect of various external stresses, a set of strata or a rock mass deformed and resulted in the formation of various geological structures, which have been observed in field at any time and described in textbooks. How these structures were generated? Since the beginning of this century, many investigators, such as those in West Europe, North America, and former Soviet Union, and even in Japan have observed, studied, and explained the genesis and development of some geological structures by using laboratory modelling and experiments. These efforts are greatly helpful in understanding their formation and related tectonic frameworks in the nature.

Professor Li Siguang had established an experimental structural geology laboratory in the 1930s in China, and performed various modelling experiments, obtaining many interesting results. Following him, Professor Zhang Wenyou gave an enormous impetus to this experimental research. Mr. Zhong Jiayou, as a capable assistant of Prof. Zhang, carried out the practical work for a long time. Zhong has mastered various experimental methods and hence obtained various results. In connection with his field observations, he inferred stress fields for several geological structures in China with gratifying achievements. During last years, delivering his lecture on experimental structural geology, he read vast foreign literature of this discipline. He digested and adopted new information, and then wrote the book *Experimental Structural Geology and Its Application*, consisting of 14 chapters, with more than one hundred of figures and 40 color plates. This book is voluminous and rich in contents. It is indeed a first initiative work in China and an elicitation for Chinese geologists.

For this reason, I strongly recommend this book to readers and write this foreword.

Huang Jiqing

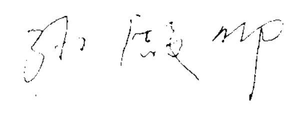
序　二

李四光先生在中国开创地质力学，倡导并亲自参加构造模拟实验，与其青年时代的学历和工作直接有关。他15岁赴日学习造船，打下了深厚的材料力学与变形分析的基础；23岁赴英，先学采矿后学地质，尤其是20年代的英国，地质构造基础理论尚处于领导地学理论思潮的环境中，使他萌生了把力学与地质学密切结合的终生宿愿。回国后他一方面带领我们一班人大跑野外，一方面在室内开展构造变形的模拟实验。当时我们一起做实验的有张文佑、邓玉书、徐煜坚、陈庆宣等。抗战时期条件很差，但是我们还是节省开支，建立实验室，开展关于节理、断层，以及多种扭动构造的一些实验，开创了中国构造实验的先河，种下了我国地质学向力学实验科学方向的种子。解放后，这棵充满活力的种子，在发展中的许多地学科研部门和学校得以生根发芽。

张文佑先生在中国科学院地质研究所，跟随李先生的先导，继续推广了实验构造学研究的发展，结合大量的野外观察和生产实践，制定了许多模拟实验研究的计划和课题，而完成这些计划的主要科研人员就是一直跟随他近30年的钟嘉猷同志。张先生病逝以后的10年，他又继续设计与完成了大量新的实验。总之，钟嘉猷同志为我国的地质构造实验研究，勤勤恳恳，不断创新地进行了近40年的工作。本书是他40年工作精品的总结，从中我们可以了解到一个实验构造地质学家对千姿百态地质构造现象的解析和认识，相信它将对地质学家，特别是未曾参加过实验工作的地质学家以诸多启发与联想。

全书从节理、断层、褶皱等基本构造要素的模拟实验以及光弹力学实验作起，直到多种组合变形的实验，从单层、单一材料的变形到多层、多种材料的多种复合变形，从微观的构造现象，直到全球尺度的构造现象，他都进行了实验探索。大量实验图解、照片、30余万字的说明与论述，堪称万千地球构造解析的缩景。

希望实验科学更多联系野外地质实际，探索构造形变规律，使之更广泛应用于找矿，地壳稳定性以及其它环境地质的研究，借以检验自己的若干设想与客观实际的比较，将会更快加速这门学科的发展，走务实、创新和发展的道路。全书了解之后有感于此，是为序。



Foreword Ⅱ

Professor Li Siguang established a discipline *Geological Mechanics* in China, while he advocated and participated in modelling experiments of structures. This is directly related with his schooling and working in his youth. As 15 years old, he went to Japan to learn shipbuilding, which provided him a sound basis of material mechanics and deformation analysis. While 23 years old, he went to Britain to learn mining industry and then geology. Especially, in the 1920s the British basic theory of geological structure was in a leading position. It led him to form a long-cherished wish to closely connect mechanics with geology. After returning home, he led our group to investigate in field on the one hand, and developed laboratory modelling experiments on structural deformation on the other hand. At that time we together with Zhang Wenyou, Deng Yushu, Xu Yijian, Chen Qingxuan and others, were engaged in the experiments. During the anti-Japanese war the working conditions were bad, but we had to economically establish our laboratory and develop some experiments on joints, faults and various torque and kink structures. It became the first basis for structural experiments in China and sowed a seed of mechanical experiment in geology of China. After 1949, the seed with plenty of vigour took root and blossomed in many scientific research sectors and universities and colleges.

Professor Zhang Wenyou, following the pioneer, Professor Li Siguang, continued to push the experimental structural geology forward. In connection with a large amount of field observations and practical data from production, he worked out many plans of modelling experiment research. Mr. Zhong Jiayou, working with Professor Zhang for about 30 years, has practically performed them During ten years after the death of Prof. Zhang, Mr. Zhong continued to design and perform a large amount of new experiments. In general, he has been diligent and conscientious in devoting himself to experimental research of geological structures for about forty years. This book is a summary of his forty-years work. From it we can know how an experimental structural geologist interprets and understands various phenomena of geological structures. It is believed that it gives an elicitation and imagination for geologists, especially for those who do not perform structural experiments.

The book deals with modelling experiments on basic structural elements, such as joints, faults and folds and photoelastic mechanics experiments, As well as experiments on multiple composite deformation, from monolayer deformation, to multilayer deformation, from single material to composite materials and from microscopic structural phenomena to global-scale structural phenomena. It includes a large number of experimental data diagrams and photos, and uses about 300,000 Chinese words in explaining and demonstrating.

I wish that such a experiment more links with field geological practice in order to explore the regularities of structural deformation, which can be used in ore prospecting, crustal stability evaluating and other environmental geologic study. The comparison of experinental and field structures is necessary. This can speed up the advance of this discipline, will be rapidly developed, a way related with real matter, creativity, and development.

I write this foreword as I felt after reading the draft.

Sun Dianqing

前　言

地球自形成开始直到现在，无时无刻不在运动着，其发展史证实了这种运动的真实性。自60年代掀起的全球地质学大变革，首先大陆漂移说得以复生，随之而来诞生了海底扩张学、板块构造学、地体学等新的学说，同时构造物理学、地球动力学等也随之进入了一个崭新的发展阶段。但它们都仅仅围绕着地球这一形变体进行研究，他们一致抓住的是对各种类型的岩石、不同性质和不同尺度的岩层与各种沉积构造类形及其组合形式，在受深或浅部、统一或局部应力作用下的形变规律研究。然而，从上述研究内容看，必须有综合性的研究手段，所以在多学科的相互穿插过程中又增生了实验构造地质学、岩石大地构造学、沉积大地构造学等新的分支学科，但他们都必须以地质构造形变场研究为基础。因为当人们掌握了它们的形变规律时，尤其是在重塑了这种形变过程时，那么，便可将人们不曾看到的地质形变过程及其形变机制展现在面前，这种形变过程的再现与研究分析手段便构成实验构造地质学。

地壳各种形变型式，包括不同尺度的物理模拟与数学模拟，是实验构造地质学的主要研究内容，它试图对现今岩石中所保留下来的各种形态变化达到重塑的效果，即实验构造地质学的研究目的，不单是用来模拟各种构造现象的形成过程，而且更重要的目的是观察它们在变形过程中各个阶段所表现的形态特征，以及与边界条件、材料性质、深度与压力之间的关系。因为这不但可以从中观察其各种构造形态的形成过程，而且也可以通过改变实验条件，观察它们的控制关系，这将使现今我们所观察到岩石中的形变现象和实验结果更加近似，即更能说明地壳岩石形变形式的生成环境、受力方式、运动方向、应力分布、应力集中、迁移、形变速率等。尤其对各种构造现象的形成是经过了漫长地质过程而产生的，所以岩石在受力作用后的全部形变过程，人们用肉眼是不可能观察到的，只能依靠地球岩石所记录的各种结果反推其形变的历史。虽然我们在自然界岩石露头上或借助于其它手段可以观察了解形变体的岩石性质、形态特征、显微结构变化及各阶段的形变特点，但它们的全部演变过程还是很难知道。

著名地质学家、地质构造模拟实验的先驱 James Hall(1761－1832)最早用模拟实验或模型实验方法再现了各种构造形态的形成过程。他首先用叠层布模拟了褶皱的形成过程，其后又用叠层湿粘土做了褶皱的模拟。1877年B. Daubree着重研究了节理的剪切面和张力破裂面力学性质的特征。1893年B. Willis对阿巴拉契亚山脉的褶皱机制研究，并通过模拟实验结果提出能干岩层(Competent)和不能干岩层(Incompetent)在褶皱过程中的形变特征，建立了岩石性质是决定褶皱类型的概念。在18世纪的100年间，构造模拟实验并没能引起地质学家的足够重视，但在B. Willis以后，1920年F. D. Adams用大理石岩材料在挤压作用下进行了流动实验，1914年W. H. Hobbs对弧形构造的形成与发展及其形态的实验研究，1920年W. J. Mead用石腊在常温下进行了褶皱形成过程的模拟实验，1926年德田贞一(S. Tokuda)关于日本海附近和日本本土弧形构造的模拟实验，1929年李四光对东亚一些典型构造形式的模拟实验，1929年Riedel用湿粘土材料模拟简单剪

切作用下的破裂实验，同年 C. M. Nevin 对盐丘的成因过程进行了模拟实验研究，1930 年 H. Cloos 用湿粘土模拟了莱茵地堑的形成过程。至 50 年代末期模拟实验研究已逐渐形成一种高潮，但从模拟各种构造形态的成因机制来说，它们并没形成一套完整的实验分析方法，以及各种相似条件的选择等。总之，还有很多问题待解决，在这以后，直到 80 年代末，实验构造地质学的研究工作不但从理论，而且从方法上又向前迈进了一大步，即有了新的突破。模拟手段可分为两部分进行，物理模拟和数学模拟，前者可以直观的观察到构造形态的形成过程，我们称之为形态模拟，如包括各种基本的构造形态，褶皱、断裂、节理地堑等，也包括大型构造体系的模拟，如碰撞带、推覆构造、幔隆构造、转换断层等，主要研究其形变过程中构造形态的产生、发展演化过程。后者则采用计算机模拟方法，从理论上求得各构造现象的形成演化历史，给出定量的结果。但作者根据几十年的工作实践认为，两种研究方法必须紧密配合，可以说缺一不可。因物理模拟的各种参数的选定，是数学模拟的基础，而数学模拟又必须通过物理模拟加以验证，而且物理模拟在量上的获得，又要依靠数学模拟给予解决。瑞典著名构造物理学家 H. Ramberg 教授(1968)所进行的工作，尤其在 60 年代末期，把物理模拟与数学模拟相结合进行综合研究，起到了推动作用。他还做了大量模拟实验研究，在大地构造的理论发展上也作了具有说服力的、细致的推导。但他研究的主要对象是围绕褶皱机制进行的，同时也考虑了在地球重力场影响下，地幔物质对流机制的实验研究。美国得克萨斯州 A & M 大学构造物理中心 J. Handin (1972)、J. M. Lognn(1978)等采用未经变形的原岩做成实验模型，放入高温高压容器中进行褶皱与断裂或其它构造形式的研究，并可从实验模型内的微观构造观察岩石在形变过程中组构方面的变化。英国地质学家 K. R. McClag 和 P. G. Ellis(1988)、法国地质学家 P. Cobbold(1990)、德国地质学家 H. U. Schwarz(1982)，他们利用砂箱或砂盒、剪切仪、拉伸或挤压仪进行了多种形式的构造模拟实验研究，并取得许多有价值的成果。

可以说实验构造地质学是一门综合性很强的学科，它们所涉及的边缘学科非常广泛。构造地质学研究的基础是岩石、地层、古生物，而实验构造地质学研究除此还必须加入数学、物理和化学，如：弹塑性力学、材料力学、金属物理、地球化学等学科。因为地壳中岩石的形变机制主要取决于温度、压力、时间(即形变速率)，当然还包括岩体所处环境的空间几何形态。为在室内达到这种自然界所给予的形变条件的相似性，就必须满足形成这些形变现象空间场中的诸多因素，因为形变体本身就是“不协调”，就是“不整合”，在形成过程中的表现就是“相”、“相变带”，这也是构造模拟实验所必须考虑的问题。

作者认为，实验构造地质学主要对各种构造形式进行相似模拟，并以此反演它们的形成过程，用来解释现今各种构造形式的成因机制。为了达到这种目的，必须建立一整套的研究方法和研究分析内容。为使实验结果更加真实，更复合于客观实际，野外现象的分析研究是最重要，也是最基础性的工作。在野外必须对所要模拟的个别构造和区域构造进行全面了解，即采用历史分析与力学分析的研究方法，把形成和形变、建造和改造联系起来，这是张文佑教授特别强调指出的。当我们把一个地区的地质构造背景，包括平面和垂向上的形变史了解清楚，并通过区域或局部构造形变特征，得出该形变体的应力作用方式，这不但对野外构造现象得到合理的力学解释，而且也是建立一个正确的实验物理模型所必须的方法。同时还要作如下几方面工作，如：古地理、古地貌、古构造、岩相变化、沉积构造、物探资料分析(包括地震、重力等)，节理与断裂力学性质分析，褶皱在空间上的组合形式

以及显微构造的研究等等。从过去已进行的实验来看，大多数对具体的构造形式进行模拟，如从一块手标本上的褶皱或节理形式，野外局部地区的一个褶皱、一条断裂、一条几十到几百公里长的褶皱带或断裂带等，但对复杂边界条件下的实验研究并没很好展开。现在已知国内外构造模拟手段，尤其通过我们多年来在实际工作中发现，不但可以模拟复杂边界条件下的构造模型，而且也有条件把不同种类的实验方法结合起来，进行综合分析。如对微观组构的形变实验研究，便可借助于高温高压实验手段对单矿物或晶体位错变化与构造形变之间的关系进行研究，另外就是对原岩本身的形变实验研究，其中包括岩石力学性质测定、岩石的蠕变实验等，还有岩组分析工作，这对微观构造形态模拟，以及地球深部构造形变模拟都有非常重要的作用和实用研究价值。

在我国构造模拟实验研究，除李四光教授 1929 年所进行的弧形构造等方面实验研究外，张文佑教授自 40 年代开始，也进行了大量的断裂、褶皱方面的实验研究，论述断裂的形成与发展规律，并结合中国与世界地质构造实际，提出断块构造理论。本书作者自 1955 年初在张文佑教授指导下，首先在中国科学院地质研究所正式建立了构造物理模拟实验室，同时开展了多种材料、不同形式和方法的实验研究。现在，我们的实验已不再是单纯考虑褶皱与断裂的成因机制问题，更多的是针对复合构造的模拟及各种受力方式下的形变规律研究，并根据国内外实验仪器的不同特点，综合设计了具有我们自己风格的模拟实验仪，如 1962 年设计的旋转剪切仪和 1990 年设计的多功能模拟仪(加入了热效应)等。然而，实验构造地质学仍属一门新学科，还需要与其它边缘学科相互渗透综合研究才能完善，而且地质学的实践场所在与其它学科相比中，是最为辽阔的。虽然目前还未引起人们的足够认识，但这一学科的兴盛时期已经到来，国内、外多数实验构造地质学家，包括通过岩石力学手段研究地质构造的人们，都逐渐转向于构造物理模拟的研究，并得到很多在理论与实际应用方面的地质学家、工程与地震学家等的支持与拥护，前途是可喜的。

本书的写作完成，与我的老师张文佑先生生前指导和鼓励是分不开的。在写作过程中，还得到黄汲清先生、孙殿卿先生、叶连俊先生、刘东生先生、马宗晋先生、王思敬先生、易善锋先生的热情关怀与鼓励。黄先生和孙先生在百忙中撰写了序言，马宗晋先生对书内很多问题提出宝贵意见以至于文字修饰，王津津为本书清绘了插图，在此深表谢意。

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Preface

The Earth has been moving from time to time since its formation. The history of its development confirms the reality of the movement. After the great revolution of geology during the 1960s, the hypothesis of continental drift revived and followed by new concepts on sea floor spreading, plate tectonics, terranes, etc. Meanwhile, tectonophysics, geodynamics and others entered a new stage of their development. But they all, regarding the Earth as a deformed body, devoted to studying various rocks, different strata in characters and scales, and different sedimentary-tectonic structures and their association patterns, and also to study various regularities of deformations under the effects of shallow or deep, unified or local stresses. From the contents involved, the mentioned above various studies must have a comprehensive approach. Thus some new disciplines and branches of sciences, such as experimental structural geology, petrological geotectonics, and sedimentological geotectonics, have just grown in the process of multidisciplinary interconnection and interaction. But they all are based on studies of deformation field of geologic structures, since that when one grasps the deformation regularities, especially when one reconstructed the structrues from the regularities, the invisible deformation processes of geological bodies and their deformation mechanisms will be present before our eyes. The experimental structural geology is just an approach to study, analysis, and reconstruct the deformation process.

The main research contents of experimental structural geology are various deformation patterns of the crust including physical modelling and mathematical simulation of different-scale geological bodies. It attempts to study variation regularities of various deformation patterns remaining in exposed rocks and to get their reconstruction, i. e., the main purpose of the experimental structural geology is not only to model the formation processes of various tectonic phenomena, but also more important to observe their morphologic characteristics expressed in every stage of their deformation process and their relation to boundary conditions, material properties, and relationship between depth and pressure. As the modelling enables us to observe not only the formation process of various structural patterns, but also their controlling relations at changing experimental conditions, it makes the observed deformation phenomena in rocks and the experimental results more close to the reality, i. e., it enable us to explain the genetic environments of rock deformation patterns in the crust, applied force, movement direction, stress distribution, stress concentration, stress transfer, and deformation rate, etc. Especially, because the formation process of various tectonic phenomena is a long geologic process, the whole deformation process of rocks under the pressure cannot be observed with eyes. The deformation history can only be inferred from the results recorded in crustal rocks. The whole process of their deformation is still difficult to understand, although we can understand lithological characteristics, morphologic patterns, microstructural variation, and deformation features in deformed bodies at every stage by observing natural rock outcrops and by other means.

The famous geologist pioneer of geologic structure modelling experiment James Hall (1761—1832) had realized firstly the formation processes of various structural patterns in modelling experiments. Since then the modelling experiment methods have been applied more widely in structural geology. He had modelled the formation process of folding using stacked cloth and then constructed a fold model from stacked wet clay. Daubree (1877) emphasized study of mechanical properties of joint shearing faces and extensional fracture faces. Willis (1893) studied fold mechanism of Appalachian Mountains and suggested the formation features of competent and incompetent rocks in the process of folding, establishing a concept of dependence of fold types on rock properties. But the structural modelling experiment wasn't given sufficiet attention in the eighteenth century. In 1920, after Willis, Adams made a flow experiment of marble under compression. Hobby (1914) carried out an experimental study on formation and development of arcuate structure and its shape. Mead (1920) made a modelling experiment of fold formation process on wax at room temperature. S. Tokuda (1926) performed a modelling experiment on Japan island arcuate structures near Japan Sea. Li Siguang (1929) had modelled some typical tectonic patterns occurring in East Asia. Riedel (1929) modelled fracture of wet clay under simple shearing. At the same time Neven carried out a modelling experiment on the formation process of salt dome. Cloos (1930) modelled the formation process of Rhein Graben using wet clay.

In the late 1950s, the modelling experimental studies had gradually become prevailing. But a complete set of experimental analysis methods hadn't been established for revealing the genetic mechanism of modelled various structural patterns and for selection of various similar conditions. In general, many questions remained to be solved. Since then, till the late 1980s, the research work of experimental structural geology took a long step forward in both theory and methodology, a new breakthrough. The modelling is divided into, physical modelling and mathematical simulation. The former provides a visual formation process of structural patterns and hence is called pattern modelling. It includes modelling of various basic tectonic patterns, such as folds, faults, joints, grabens and modelling of large-scale tectonic systems, such as collision zone, nappe structures, mantle upwelling, transform fault, studying its generation, development and evolution. The latter is to theoretically study the formation and evolution history of various tectonic phenomena and to provide quantitative results by using computer modelling methods. But from the experience of tens years, the author considers that two branches must be connected and closely cooperated, because the selection of various parameters for physical modelling is a basis of mathematical modelling, which in turns must be tested by physical modelling, and the acquisition of data in physical modelling depends also on mathematicad modelling. Famous Sweden tectonophysician, Prof. Ramberg (1968) has carried out an integrated study of both physical and mathematical modelling. He performed a lot of modelling experiments to advance geotectonic theory. But his study was mainly on the mechanism for folding and also on the mechanism for mass convection in the mantle by the effect of earth's gravity field. Germen Handin (1972) and Lognn (1978) in the Tectonophysical Centre of Texas A & M University, U. S. A. performed experimental modelling on undeformed rocks placed in high-temperature and high-pressure vessels for studying fold and fault and other structural patterns, observing fabric variation in rocks during deformation process. Britain geologists McClag and Ellis (1988), French geologist Cobbold (1990), and German geologist Schwarz (1982), used sand boxs or sand models, shear machines, extensometers or compressors for modelling various types of structures and obtained valuable results.

Therefore, experimental structural geology is a high-integrated science branch, which involves a wide scope of multiple disciplines. Structural geology is based on petrology, stratigraphy and paleontology. Experimental structural geology must be connected with mathematical and physical sciences, such as elastoplastic mechanics, material mechanics, metal physics, geochemistry. This is because the deformation mechanism of rocks in the crust depends mainly on temperature, pressure, and time (i. e., deformation rate), of course, including the spatial geometry of environment in which the rocks are located. In order to get similar deformation conditions in laboratory to those of the nature, the assumed conditions must ensure the formation of studied deformation phenomena. Since the deformed bodies are often "discordant" or "unconformable", appearing as "phase" or "phase transition zone". these uncontinuities must be considered in structural modelling.

The author considers that experimental structural geology is to model the similarity of various structural patterns and accordingly to make an inversion of their formation process to explain the genetic mechanism of various existing tectonic patterns. For this purpose, a set of research methods and analysis contents must be established. In order to obtain results more close to actual situation, study and analysis of field phenomena is an important and most basic work. It is necessary to fully understand individual and regional structures that will be modelled. In other words, the method of historic analysis and mechanical analysis should be applied a method to connect formation and deformation, or construction and reworking. This was often emphasized by Prof. Zhang Wenyou. When we well know tectonic background of a region, including its deformation history reflected in planes and on profiles, we can find out stress acted on deformed bodies by analysis of deformation characteristics of regional or local structures. Thus, We not only can reasonably explain the field tectonic phenomena, but also can work out an exact method for experimental physical models. Meanwhile, the following data are necessary, too: paleogeography, paleogeomorphic, paleotectonics lithofacies change, sedimentary structure, geophysics (including seismic sounding and gravity), mechanical analyses of joints and faults, and spatial association pattern of folds and microstructures. Most of preocous modelling was concentrated on specific structural patterns, from fold or joint patterns in hand specimens to a local or regional fold or fault, or even to a fault zone or a fold belt tens to hundreds kilometers long. But few or no experimental studies under complex boundary conditions had been well developed. The recent approaches for structural modelling, at home and abroad, including those we have developed in many years practice work, can be used not only in modelling structrues under complex boundary conditions, but also in comprehensive analysis of experimental results of microfabric deformation in connection with various kinds of experimental methods. And the relation between dislocation and structure of single mineral or single crystal can be studied at high-temperature and high-pressure conditions. Moreover, experimental study of deformation of intact rock itself, including determination of mechanical properties of rocks, experiment on rock creep, and rock fabric analysis were also carried out. These results are very important and valuable for modelling of deformation of microstructures and deep structures in the earth's interior.

In addition to the experimental study of arcuate structure by Prof. Li Siguang, Prof. Zhang Wenyou since the 1940s, performed many experiments on faulting and folding processes to reveal the regularities of fault generation and development. In connection with actual geological structures in China and in the world, he suggested a block tectonics theory. Under the direction of Prof. Zhang Wenyou, the author had first established a tectonophysical modelling laboratory in Institute of Geology, Chinese Academy of Sciences and carried out experiments on many kinds of materials for study of different structural patterns by using different methods. Now our experiments can be made not only for study of genetic mechanism of folds and faults, but also for modelling composite structures and for studying deformation regularities at different pressure conditions. We have designed a set of modelling experiment devices of our specific style based on different performances of existing domestic and foreign experimental devices, such as rotating shear device designed in 1962 and multi-function modelling device with heat effect designed in 1990 etc. However, experimental structural geology is still a new science branch. It needs to be perfected by further combination with other sciences. Geology has a much more wide practiced area than others. It makes experimental structural geology prosperous. Many experimental structural geologists, including engineering geologists and seismologists, tend to engaging in tectonophysical modelling. Thus the prospective of such science branch is encouraging.

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