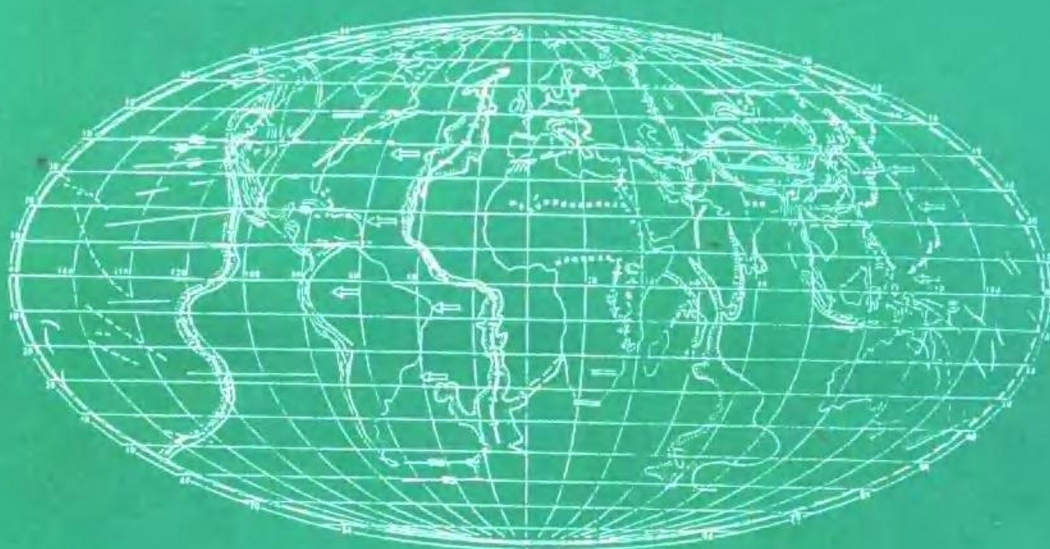


地质力学的方法与实践

第五篇(上)

地质力学在矿产资源勘查中的应用

刘 迅 等 编著



地质出版社



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· 北 京 ·

内 容 提 要

构造体系控矿规律问题,是地质力学基础理论和实际应用的重要问题之一。本书汇集了地质力学在矿产资源勘查应用中的部分典型成果,主要包括:构造动力作用下岩石矿物形变相变与元素聚散的关系,成矿构造应力场的模拟与控矿规律以及地质力学理论和方法对石油、煤田和金属矿产的勘查和预测的指导作用。本书是对广大地球科学工作者从事矿产勘查、科研和教学实践工作成果的总结,实际资料十分丰富,特别是直观性图件很多。

本书可供地学工作者,特别是从事构造和矿产勘查的地学工作者参阅。

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序

与地质力学密切相关的第一篇文章“地球表面形象变迁之主因”发表于1926年。构造型式和构造体系的概念是在本世纪20年代末期提出的(Lee, 1929)。结合中国大陆及东亚地区的地质实际,根据地球表面实际见到的不同型式的构造体系来论断地壳运动的,是1939年出版的《中国地质学》(英文版)一书。地质力学作为一门学科是1941年秋冬之际,李四光教授应厦门大学校长萨本栋教授之邀为该校数学力学和物理系(当时由于抗战该校迁至福建长汀)的同学讲演时提出的。之后,李先生开始写《地质力学之基础与方法》,并于1945年完稿。该书稿曾由重庆大学地质系油印。当时,在重庆的中国地质学会同仁还举行过多次学术报告会。该书于1947年春由中华书局正式出版。

1949年10月1日中华人民共和国成立后,为了适应国家经济建设需要,开展了大量地质工作,包括矿产勘探、工程地质、水文地质以及国家建设中出现的其他各种地质问题。地质力学在李四光教授亲自领导和参与下投入到国家建设洪流之中,与其他地质科学一样取得了迅速的进展。60年代初,内部出版了《地质力学概论》。1970年,内部刊印了《天文、地质、古生物资料摘要(初稿)》一书。上述两本书均由李先生亲自执笔。书中不少的地质实际资料是由各方面的地质工作者提供的。

李四光教授在他早年和晚年的著作中均曾提出过:地质力学的主要目的是研究地壳构造和地壳运动的规律,探索地球运动的起源;研究各种矿产在地壳中的分布规律以及现代地壳运动的程式,借以指导矿产资源预测以及地壳稳定性评价,防治可能发生的各种自然灾害。

李四光教授在其遗著中曾提示我们:研究地球科学,要从地球看宇宙,要以事物的生因、发展和系统联系的观点,从事实现象追寻本质的要求,来研究地壳运动所产生的各种地质现象发生、发展的规律。

从李四光教授1926年发表第一篇文章起至1971年4月底他逝世这45年间,他为地质力学学科的建立及应用,做了大量的实际工作,开辟了地壳运动研究的一条新途径,为发展地球科学作出了重要贡献。从李四光教授逝世到现在,许多地质工作者沿着他开拓的道路又进行了21年的工作。从1926年到现在这68年间,在国家经济建设和人类社会生活需要的各种自然资源的寻找以及与人类生存相关的各种自然灾害的斗争中,地质力学伴同其他地球科学做了大量的有益工作。《地质力学的方法与实践》丛书,就是这项工作的一种记录。今后,我们将把这项工作继续下去,为认识自然和改造自然作出新的贡献。

孙殿卿

1994年11月14日,北京

PREFACE

The first paper closely related to geomechanics entitled the "Main Cause of the Changes of Superficial Features on the Earth" was published in 1926. As for the conception about the tectonic patterns and tectonic systems, it was put forth at the end of the twentieth century (Lee, 1929). It was in the book entitled the "Geology of China" (in English version) published in 1939 that the crustal movement had been proved by the author with the tectonic systems of different types actually found on the surface of the Earth, and in combination of the practical geological situation in the mainland of China and East Asia. Geomechanics as a branch of sciences was established in the autumn and winter time of 1941 by Prof. Li Siguang (J. S. Lee) during his lecturing for the students from the Department of Mathematics, Mechanics and Physics of the Xiamen University (moved to Changding City, Fujian Province owing to the anti-Japanese War) at the invitation of the Dean of the University. Later on Prof. J. S. Lee began to prepare the book on "The Basis of Geomechanics and Its Method", which was completed and was mimeographed by the Department of the Geology of the Chongqing University, Sichuan Province in 1945, and at the same time it was then once used as lectures for the colleagues of the Geological Society of China at Chongqing City. The particular monograph was officially published by the China Publishing House in the spring of 1947.

Since the founding of the People's Republic of China on October 1, 1949, in order to meet the need of the economic construction of the country vast amounts of geological work have been conducted, including prospecting for mineral resources, engineering geology, hydrogeology and various geological problems that have been occurred during the economic construction of the country. So geomechanics has been thrown into the mighty torrent of the economic construction of the country under the direct guidance of Prof. J. S. Lee himself and his personally taking part in the work, and as other branches of geological sciences, geomechanics in this way has also gained a rapid development. At the beginning of the 60's of this century the monograph: "An Introduction to Geomechanics" was published as a restricted publication, and in 1970 the monograph: "Astronomy, Geology and Palaeontology" (first draft) was also published as a restricted publication. All the above-mentioned monographs were written by Prof. J. S. Lee himself personally, by using a big amount of practical geological data provided by vast numbers of geological workers from various fields.

In his works published in his early and late years, Prof. J. S. Lee had repeatedly remarked that the major objective of geomechanics lies in the study of the regularity of crustal tectonics and crustal movement, in probing into the origin of the movement of the Earth, and in investigation on the regularity of distribution of various mineral resources in the earth crust, as

well as on the mode of occurrence of the modern crustal movement, with the purpose of guiding the prognostication of mineral resources and making the evaluation of the stability of the earth crust, thus preventing from the possible occurrence of these and those natural hazards.

In his posthumous works, Prof. J. S. Lee used to mention to the audience that in the study of geological sciences one must view the cosmos from the Earth and investigate the regularity of occurrence and development of various geological phenomena produced by the crustal movement from the viewpoint of the origin, development and systematic relations, and in accordance with the requirement of study on any matter by probing into the essence of things judging from the phenomena of the fact.

During the forty five years of his life, starting the publication of his first paper in 1926, and being ended with his death at the end of April in 1971, Prof. J. S. Lee had completed large amounts of practical work for the establishment and application of geomechanics as a branch of sciences, and had opened up a new approach to the study of the crustal movement, thus making a great contribution to the development of geological sciences. From the time of his passing away till the present, many geological workers have conducted great amounts of work for twenty one years along the path Prof. J. S. Lee had opened up. In the 68 years from 1926 till now, in the prospecting for natural resources needed for the economic construction of the country and social daily necessities of human beings, as well as in the struggle against various natural hazards that are closely related to the existence of human beings, together with other branches of sciences geomechanics has done a lot of useful things. The "Method and Practice of Geomechanics" series represents itself records of this kinds of work. In the future we will certainly keep taking this kind of records in order to make a new contribution to recognition and remaking of nature.

Sun Dianqing

November 14, 1994, in Beijing

《地质力学的方法与实践》编辑委员会

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INTRODUCTION

The geosciences circles have now been heartily investigating the lithosphere and global dynamics in different ways. Meanwhile, the geomechanic workers have also actively deepened their investigations on the dynamics and kinematics of the Earth in a way created by themselves in the passing years, namely by combining the geology, geophysics, geochemistry and mechanics with one another, and through the study of geological structures on the earth crust and crustal movement.

So although the earth crust tends to constitute only a thin layer in the whole texture of the Earth, yet it has recorded and preserved all the features formed in the course of origin, development and evolution of the Earth; the results of the influence from the atmosphere surrounding the Earth, the moon rotating around the Earth, solar system, and the other celestial bodies upon the earth crust; as well as the traces of the outer-space events, such as the fall of the cosmic dust and meteorites. Besides, in the earth crust there must have undoubtedly been recorded and preserved in a concentrated way all the expression, under high temperature and pressure, of physical and chemical changes and motion of matter in the litho-, hydro-, air-, and bio-spheres of the Earth.

In view of this, if the other approaches of the study of geodynamics are considered to be scientific and effective, then the geomechanics with the earth crust being as its target of research should also be valid and reasonable, since it keeps to the principle of going deep into the study of geodynamic and kinematic problems concerning the structure and texture of the litho-, hydro, air-, and bio-spheres of the Earth, mutual actions of the later, as well as the origin, evolution and motion of the Earth in a way proceeding from the outside to the inside, from the simple to the profound, and from the part to the totality through the study of the geological structures of the earth crust, the motion and regularity of distribution of matter in the earth crust, and the origin and evolution of the crustal movement.

For this reason, the geomechanical workers have conducted a great volume of worker and have gained lots of meaningful results through their protracted struggle, and with their own effort and under the support of the interrelated branches of sciences and vast numbers of scientists. The frequent and timely comprehensive analysis and summation of these achievements and results are of great importance not only to the development of geomechanics, but also to the development of the whole geological sciences themselves and to promoting geomechanics to provide a better service for social development and national economic construction. With the support from the Ministry of Geology and Mineral Resources and the Chinese Academy of Geological Sciences, the publication of the *Method and Practice of Geomechanics* series has been

placed in the "Eighth Five-Year Plan of the Development of Natural Sciences" as an important project of basic researches to be implemented under the guidance of Academician Sun Dianqing.

As early as at the beginning of the 60's of this century, Prof. J. S. Lee, the founder of geomechanics used to plan to organize labour power to compile a set of the *Method and Practice of Geomechanics* series, aiming at the summation of the achievements and results of the research and practice of application of geomechanics. For this purpose, Prof. J. S. Lee personally took a hand in drafting an outline for the particular series, and decided to take the monograph of his *An Introduction to Geomechanics* as the first volume of this series. Later on, Prof. J. S. Lee made comments on the revision of the monograph *An Introduction to Geomechanics*.

The present comprehensive research and summation is exactly the implementation of the behests of Prof. J. S. Lee, modifying the first volume and compiling six books of four volumes and a sheet of Global Tectonic Map, namely:

Volume I, *An Introduction to Geomechanics*, by J. S. Lee, modified by Sun Dianqing and Others;

Volume II, *Separate Treatises on Tectonic Systems* (Individual papers on typical tectonic systems of China) by Wang Zhishun and Others;

Volume III, *Rock Mechanics and Analysis of Tectonic Stress Field*, by Chen Qingxuan, Wang Weixiang, Sun Ye and Others;

Volume IV, *The Problems on Crustal Movement*, by Gao Qinghua and Others;
The Problems on Recent Crustal Movement, by Ma Zongjin and Du Pinren;

Volume V, *Application of Geomechanics in Prospecting for Mineral Resources*, by Liu Xun and Others;

Application of Geomechanics in Environmental Geology, by Shao Yunhui and Others;

An Outline Map of Global Tectonic Systems, by Miao Peishi and Others.

As the *Method and Practice of Geomechanics* series has been compiled on the basis of comprehensive analysis and summation of the results of research and practice conducted by vast numbers of geomechanical workers and scientists engaged in related branches of sciences, so it should undoubtedly be regarded as a crystallization of common effort of all the people concerned. Except for the monograph *An Introduction to Geomechanics*, for all other volumes of the series we use the term "Compilation", to mean that in the particular series results of research by other people are included, which the authors beg to acknowledge hereby. So and comments on possible oversights any omissions and mistakes in quotations are welcomed.

Editorial Board of *The Method and Practice of Geomechanics*

引 言

地球科学界正热烈地通过各种不同的途径研究岩石圈和全球动力学。地质力学工作者也积极地按照自己多年来形成的途径,即将地质学、地球物理学、地球化学和力学等多种学科结合起来,通过对地壳地质构造和地壳运动的研究,以深化地球动力学和运动学的研究。

因为,地壳虽然是地球整体结构中极薄的一层,但她却记录和保存下了地球形成、发展、演化的踪迹;记录和保存下了地壳以外,诸如包围地球的大气层,围绕地球转动的月球,太阳系,以及其它各种星体对地壳发生的影响,宇宙微尘和陨星之类的坠落等(星)球外事件的遗迹;记录和保存下了地壳以下,在高温高压条件下,地球各圈层物质的物理与化学变化和运动,以及由重力、日月潮汐作用和地球自转而产生的运动,都不可避免地要集中反映到地壳中来。

由此看来,如果其它研究地球动力学途径是科学的、有成效的,那么,地质力学以地壳为对象,通过对地壳地质构造、物质的运动和分布规律、地壳运动的起源和演化等的研究,由表及里、由浅及深、由局部到地球整体,深入地研究地球各圈层的组织构造、相互作用,地球的起源、演化和运动等一系列地球动力学和运动学问题,是不无道理的。

为此,地质力学工作者经过了长期的奋斗,在她自己的努力和各相关学科、广大科学工作者的支持下,做了大量的工作,取得了很多、很有意义的成果。经常地、及时地综合分析研究、总结这些成果,不仅对发展地质力学具有重要意义,对于发展地球科学,促进地质力学更好地为社会发展和国民经济建设服务,也不会没有意义的。地质矿产部和中国地质科学院将《地质力学的方法与实践》列为“八五”重要基础研究项目,在孙殿卿院士指导下予以实施。

早在60年代初,地质力学的创始人李四光教授就计划组织人力,编著一套《地质力学的方法与实践》丛书,总结地质力学研究和实践成果。为此,他亲自草拟大纲,并将他自己主持撰写的《地质力学概论》专著做为该丛书的第一篇。其后,他还提出了对《地质力学概论》进行修改的意见。

这次的综合研究和总结工作,就是实现李四光教授的遗愿,修订第一篇,编著四篇六本书和一幅全球构造图,即:

- 第一篇** 地质力学概论 李四光著,孙殿卿等修订
- 第二篇** 构造体系各论(中国典型构造体系分论) 王治顺等编著
- 第三篇** 岩石力学与构造应力场分析 陈庆宣、王维襄、孙叶等编著
- 第四篇** 地壳运动问题 高庆华等编著
现今地壳运动问题 马宗晋、杜品仁编著
- 第五篇** 地质力学在矿产资源勘查中的应用 刘迅等编著
地质力学在环境地质中的应用 邵云惠等编著

全球构造体系纲要图 苗培实等主编

《地质力学的方法与实践》既然是在广大地质力学工作者和有关学科科学工作者科学研究与实践应用成果基础上，经过综合分析研究、总结完成的一套丛书，无疑也是大家劳动成果的结晶。因此，除《地质力学概论》一书外，其它各篇册我们都用了“编著”一词，表示这一套书中还包含了他人的成果，并在此予以致谢。如果有什么疏漏和引用上的误解，也请予以批评指正。

《地质力学的方法与实践》编辑委员会

前 言

李四光教授在他的名著《地质力学概论》中指出：各种构造型式的各级组成部分对矿产往往呈现一定的关系。这种关系虽然是多方面的，相当复杂的，但是一般地说，还是有规律可寻的。

随着地质力学工作的深入开展，各级构造型式对矿化带和矿田的控制作用（包括大、小矿带的分布规律），岩层、岩体内流体（包括油、气、水等）运动的一般规律，岩浆、矿液和气化物质的通道，各种成因类型矿床在构造体系中的成生联系及其找矿意义，含矿变质岩相带与构造型式的关系，以及和某些沉积矿床有关的海进海退的规律等方面，已经积累了一些资料，揭示了一些规律。但还应当广泛而深入地开展这些方面的研究工作。这是地质力学基础理论的重要组成部分，也是应用于实践的重大研究课题，对国民经济的发展具有极其重要的意义。

我们知道，对于成矿规律问题国内外许多地质工作者进行过悉心研究。李四光曾经指出：地壳中的矿产是受成矿条件与分布规律的双重控制的。成矿条件主要决定于岩性和有关岩体成生时的环境以及它们之间的相互关系，这也就是通常所谓的物质来源和元素的地球化学特性；分布规律，一部分和生成的条件有关，但主要是决定于构造体系，不待说，构造体系也有时影响成生的条件。这可以从矿化分布总是与某些具体构造要素有关来予以理解；而具体的构造要素总是属于这一个或那一个构造体系的。一个构造体系，有它自己的发展过程，每一成矿区或成矿带也有它自己的成矿历史。而成矿作用总是与构造体系发展的一定阶段相联系，这就构成同成矿构造体系的概念。一定的矿区、矿带总是受一定的构造体系所控制。而构造体系之间又有复合与联合的关系，这就必然造成矿产分布的特殊规律。同时，某一类型矿带、矿田和矿床乃至矿体或矿脉常分别受不同等级的构造体系或两个、两个以上的构造体系的控制，这就构成了分级控制的现象。若再解剖一个构造体系，显然不同力学性质、不同级序的结构要素，特别是构造体系本身所具有的某些规律性特点，对成矿也往往有不同的控制作用，等等。这些不同情况所显示的构造体系对矿产分布的控制作用，就构成了我们研究矿产分布规律的基础。当然，还有许多其他控制因素也应该结合起来加以分析，例如，成岩成矿的物理化学条件或环境，特别是成矿元素的地球化学行为等。

因此，从探讨大的区域性构造对矿产分布的控制作用开始，逐步进行矿区或矿田构造控制的研究，并把它们联系起来做为一个整体看待，我们就可以看到一个地区或地带，大中小互相联系的统一的构造体系控制矿产分布规律的生动图画。

构造体系控矿规律问题，是地质力学基础理论和实际应用的重要问题之一。它涉及的问题很多，研究内容相当广泛。如在构造动力作用下岩石矿物形变相变与元素聚散关系的研究，成矿构造应力场的模拟及控矿规律的研究，以及地质力学理论和方法对石油、煤田和金属矿产的勘查和预测的指导作用，等等。本书汇集了这方面的部分典型研究成果，供

有关方面参考。

《地质力学在矿产资源勘查中的应用》一书是在广大地球科学工作者从事矿产勘查、科研和教学实践和研究成果的基础上编写而成的，是集体劳动的结晶。全书共九章，各章撰稿人是：第一章，王小凤、陈宣华；第二章，吴淦国；第三章，王成金、王义强；第四章，赵寅震；第五章，刘迅；第六章，乐光禹、徐旃章、黄继钧；第七章，杨明桂、梅勇文；第八章，刘泽容、邓俊国、王伟锋；第九章，李涛。此外，还有一些地质力学同仁也积极热心地为本书撰写了稿件，由于篇幅所限，未能列入，仅向他们表示衷心的感谢和歉意。对本书中存在的问题和不足，欢迎广大读者批评指正。

编 者

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