第五卷·地质力学(2)

Volume V Geomechanics (2)

李四光全集

The Complete Works of Li Siguang

湖北人民出版社

The Complete Works of Li Siguang

李四光全集

第五卷·地质力学(2)

Volume V Geomechanics (2)

湖北人民出版社

编者说明

本卷收集作者《地质力学概论》一书的中文版与英文版。《地质力学概论》完稿于1962年，当时由地质部地质力学研究所刊印内部发行，1973年由科学出版社正式出版，其英文版则于1984年由科学出版社与纽约Gordon & Breach科学出版公司联合出版。本卷编辑过程中，为了照顾全集各卷的编排体例，将英文部分置前，中文部分置后，并对原书中的文字、标题及标点符号作了一些修订，部分图版和图例缩小了篇幅。

目　录

Introduction to Geomechanics

Preface

What do the contents and tasks of geomechanics involve? Many geologists have come to consider this problem. Although some of the geologists and geophysists would not like to use the term geomechanics in treating tectonic problems, their work is actually directed to one or the other aspect of geomechanics. Hence, there emerges an urgent need on the part of geomechanists to summarize their working experiences and knowledge in this area and to present them in a broad outline for open discussion.

This book, together with others to be published in the future, is written for this purpose. Whether or not it can answer satisfactorily the questions mentioned above is left to the reader's judgment.

Needless to say, this is only a preliminary summary to be supplemented and advanced by a great amount of future work. The working methods and the fundamental viewpoints presented in this book have been repeatedly modified through practical work. The compilation and printing of these books will not be in vain, if we can find from them the direction of the development of geomechanics and establish some important steps toward its working methods so as to provide solutions to

the problems arising from geological explorations and to lay some grounds for the study of crustal movements.

As so vast an amount of information and so many suggestions are involved in this book, it is difficult here to enumerate them all. This defect can, however, be partially, though not completely remedied by consulting the list of references.

Chapter I
Essentials of Some Traditional Concepts Concerning Geological Structures

I. Some Important Viewpoints Relating to the Discussion of Crustal Movements

In recent years, there have arisen long latent but vital problems in many fields of natural science, shaking some of the traditional concepts and promoting their development along a new line, although natural science, as a social ideology, is in general believed not to belong to the suprastructure.

The problem of crustal movements is just such a subject in modern geological sciences. It involves a variety of subjects and a wide range of aspects, the most striking arising from the following:

(1) Palaeogeography Mainly concerned with problems related to the rise and fall of continents and oceanic floors, transgressions and regressions, separation or partial inundation of large and small land masses and the possible progressive ac-

cretion of continents, and so on.

(2) Igneous activity Largely the distribution or scattering on the surface and in the upper crust of the various silicic, intermediate, basic and ultramafic rocks, especially the abundant granite, andesite, basalt and peridotite, their history of activity, and the possibility of the flow and differentiation of lava (magma) in and underneath the lower crust.

(3) Palaeoclimatology Mainly problems related to the change of the geographic positions of the palaeoclimatic zones, the extension of warm, or hot—dry or hot—humid climates to present polar regions, and the occurrence of ice — caps or glaciers on a large scale.

(4) Palaeontology The distribution of fossil assemblages and lines of their migration during various geological periods, and problems related to palaeoclimatic change.

(5) Geothermometry Including problems relating to the thermal history of the earth, the most important being (a) the lower crustal or subcrustal contraction and expansion as a result of heat loss or gain; (b) the possibility of the liquidation or softening of the same layers resulting from heat accumulation and (c) the effect of the change of local thermal state upon the texture of rock layers or bodies as well as upon their equilibrium conditions.

(6) Seismology Chiefly problems of the distribution of earthquake helts and the interpretation of deep, shallow and man—made earthquakes.

(7) Geodesy Concerning primarily the change of dis-

tances between certain localities and the change of longitudes and latitudes.

(8) Gravity field Primarily problems related to the origin of the regional positive and negative gravity anomalies and to the ways and extents of isostatic compensation in addition to the complex structures of many crustal parts resulting from the constant tendency to reduce their potential energies in a gravity field.

(9) Palaeogeomagnetism The more important being the variation of the geographical positions of magnetic poles through geological times shown by rocks from different parts of the crust.

(10) Astrogeology Principally the relation between the motion of the planetary earth and its surface features and interior structure, the possible effects of tides and solar activity upon crustal movements and the correlation between the surface features of the earth and those of the moon or other planets and the origin of their similarties.

(11) Structural geology Including various deformations which rock layers or rock bodies of various parts of the crust have undergone——i. e. structural features comprising folds of different scales and forms, fractures, cleavages and schistosities, the passageways of the intrusion and extrusion of lava (or magma), lineations of regional metamorphic belts, extents of ore fields and the distribution of mineral veins.

The data and argument from 1—10 are fairly significant for the solution of crustal movements, i. e. for the determina-

tion of the manner of crustal movement and the inquiry into its origin. As the crust is far from an ideal rigid body, there must have been left in its various component parts the imprints of crustal movements. Therefore, conclusions drawn from the above aspects should be capable of fully explaining the origin of all structural phenomena. This is a rigorous test and is decisive to the problem. Unfortunately, there presently exist some radical problems concerning the realm and contents of structural geology. It is just the disclosure of such radical problems that stimulates us to find out the principal contradictions in our working methods so that we can advance.

Structural geology has almost as long a history as geology itself. Zhu Xi mentioned in the twelfth century in China that "the mountains appear wavy when seen from a height"; Steno first noticed the bending of rock layers in the middle seventeenth century in western Europe. There is much divergence of views or terminology in some instances, or even of the meaning of the same terms among various schools of structural geology. This may seem difficult to be understood at first glance, for these are not exceptional cases. But in view of its emergence primarily from regional geology, the development of structural geology would be naturally limited to a great extent to the regional geological conditions. It is thus quite natural for geologists to use the structural phenomena which they are familiar with in some regions and the "law" obtained therefrom as criteria for the consideration of the structures occurring in other regions. In view of this, it is therefore not surprising that there

are such major differences in the field of structural geology.

Despite the great and numerous differences, the views on structural geology or tectonics can be, in general, summed up into two schools:

(1)Considerations from the construction of the crust.

(2)Considerations from the structure of the crust.

In order to advance the advantages of each of these two schools and to achieve the free intercommunication and mutual complement between them it is reasonable to allow them to have an independent development along their own lines.

If the analysis of tectonics from the angle of stratigraphical record or "structural layer" can be thought of as a historical view of the development of tectonics, can we not say that the statement of the continued and successive changes as embodied by the generation, development, compounding and transformation of tectonic systems and by the appearance of new structures in an area on the foundations of the more or less stabilized old ones is a historical point of view? If the crustal structure is analyzed only from its construction with little or no consideration or attention paid to the structures themselves, then it will suffer still greater disaster in addition to the loss brought to it here and there by some enthusiastic workers who have attempted to develop it.

II. Some Aspects of the Study of Tectonics from Crustal Construction

When the types of rock layers constituting the landmasses or crustal parts, large and small, as well as the form of their combination and the geometrical shapes of the landmasses were taken as the major aspect of geological structures, the following subjects and the related problems became the main targets for structural geology or "geotectonics".

A. Division of the Crust into Basement and Sedimentary Covers and the Course of Their Individual Formation

What is here called basement is composed mostly of old metamorphics associated in some cases with complex igneous rocks. There is generally a striking unconformity between it and the overlying sediments. It is evident that all the old metamorphic rocks in various regions of the world were not produced by going through the same process over the same period, and they cannot be assumed to be all precambrian. Igneous activities found in the old metamorphics are observed, in some instances, to have some connection with the distribution of old mineral deposits. The construction frame of the cover rocks not only reflects the course of the whole geological history after the formation of the basement rocks, but is also closely related to the formation and preservation of sedimentary ore deposits. Research in this respect either from the so-called palaeostruc-

tural or from the palaeogeographical side is of profound significance for uncovering the history of the construction of the upper crust.

B. Division of the Crust into Subsidence and Uplift Regions and the Process of Transformation of Their Relative Undulations

An uplift region may be one either of erosion or of sedimentation while a subsidence region is generally one of sedimentation. Only from a study of the distribution of the continually deposited sediments through successive geologic times and of the change of their facies and thickness over a particular part of the crust, can an inference of the undulation process of that part and its neighbours be drawn.

Some of the uplift regions belong to the active or stabilized fold belt; in this case, it is generally called an orogenic belt. It must be pointed out here that an orogenic folding is not to be equated with the building of great mountain chains. In addition, there is another kind of uplifting, which, occurring slowly over a wide area and involving no folding, is called epeirogeny.

Subsidence regions on the continental crust comprise various types of basins, troughs and foredeeps adjacent to the fold mountains transformed from geosynclines.

C. Division of the Crust into Geosynclines and Platforms and the Processes of Their Transformation

A region in which a thick sequence of sediments as a result of great accumulated subsidence was strongly folded and often associated with igneous activities is generally regarded as a geosynclinal area. Conversely, a region in which the less thick sedimentary cover overlying a consolidated basement shows little or only gentle folding is generally referred to as a plaftorm. Such a division is, in general, correct in the description of the large structural features of the crust. However, it is now realized by many geologists that a geosyncline is gradually reduced in extent after its transformation from an area of great subsidence into fold mountain ranges; that is, it tends to turn gradually into a platform. It is also realized that parts of a plaftorm would later become active again. This is known as rejuvenation. The problem of whether the extensive subsidence belts associated with such rejuvenated uplifting, e. g. some marginal zones of the present eastern Asiatic Continent, can be comparable with the initial process of a common geosyncline is worthy of consideration.

It has been revealed in recent years by extensive geophysical prospecting and drilling that the sedimentary rocks in some parts of the so-called platform are no less thick than those of the geosynclines, and are rather strongly folded, and in some cases, accompanied by igneous activities. In this case, the criteria originally set for the division of the crust into platforms

and geosynclines will lose, to some extent, its significance and validity. Consequently, some geologists proposed the term intraplatformal folds for folds in such areas. And any such area, e. g. South China, is regarded as a transitional area. But unfortunately, no demonstration was made as to the question of the nature and location of its neighbouring platform and geosyncline. Thus, as its name may suggest, what is called a transitional area is obviously problematical.

D. Inference of the Configuration of the Undulations of the Basement from the Characteristic Features of various Fold Types

There is general agreement on the characteristic shapes of folds occurring in geosynclines with which geologists are familiar. But considerable difference of opinion exists on the presence of folds within the so-called platforms, a matter which was considered to be of no great significance or was even ignored by some geologists in their description of regional structures; perhaps at most, attention was paid only to the shapes of some fold types, e. g. a fold with a flat top and steep limbs (case-like fold), or a chevron fold (comb-like fold) which were believed to reflect only the configuration of the basement undulation. But it is difficult to seek a satisfactory explanation for such folds as the isoclinal fold, the recumbent fold accompanying a large thrust fault, and for the schuppen structure and decollement as well, simply from the assumption that they are reflections of the basement undulation.