THE GEOLOGY OF CHINA

BY

J. S. LEE, D.Sc.,

Professor of Geology in the National University of Peking,
Member of the Academia Sinica,
Foreign Correspondent of the Geological Society of London, etc.

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PREFACE

THE present volume has largely developed out of a part of a series of lectures delivered in British Universities during the years 1934 and 1935, under the auspices of the Universities' China Committee in London. Although a certain amount of material has been added to each of the lectures which are here incorporated in Chapters I-IX, an attempt is made to maintain, as far as possible, the original method of presentation. If I have not failed in my objective, such a method of treatment may prove to be more palatable than presentation in text-book style. To meet the obvious requirements of serious students of Chinese Geology and field workers the essential data of stratigraphy are assembled in Chapter X in a simplified form.

Approaching the subject, as I try to, from the structural point of view, it has been felt necessary to consider the steps by which the basic conception of tectonic forms is arrived at. Comparative study of common tectonic types recognized in China naturally brings the whole world into our view; and in order to pursue the argument to a logical end an exploration into the borderland between Geology and Geophysics becomes inevitable. These aspects of the subject are briefly dealt with, but not without hesitation in a work of this nature.

Phonetic notations are not introduced in spelling the geographical names; for they are too numerous, and, if applied, would only increase the difficulty of reading; moreover, they do not necessarily convey the right pronunciation of the words.

It would be too long a list if I were to enumerate the names of my British friends and colleagues who have contributed illuminating discussions on different parts of the subject-matter. I have, therefore, to be content with a general acknowledgment, inadequate as it is.

My thanks are due to Dr. W. H. Wong, the Director of the Geological Survey of China, for free use of the publications of the Survey, including illustrations, and also to Mr. C. P. Liu, the Director of the Hunan Provincial Geological Survey, for similar reasons. I am indebted to Dr. Arnold Heim for his voluntary supply of valuable information regarding the remote regions of the west and extreme south of China, and to Dr. G. B. Barbour for his frank and friendly discussion on the treacherous problem of Pleistocene Climate. I am under obligation to Dr. L. D. Stamp for his active interest in the publication of this book, and to Messrs. Thomas Murby and Co. for their ready co-operation.

With the limited time at my disposal I could hardly have completed this work without the help of Dr. C. C. Yu in compiling the lists of references, and of Dr. H. D. Thomas, of the British Museum (Natural History), in undertaking the task of reading the proofs and compiling the index. No adequate expression of thanks can compensate for the drudgery of such work. I wish to thank Professor L. J. Wills for his help in many ways, especially for reading my manuscript, with valuable criticisms, of the chapter on Pleistocene Climate in China, and also for granting me the privilege of using the laboratory of the Geological Department of the University of Birmingham in conducting the preliminary experiments with a rotating hemisphere. In this connection I am indebted to Professor W. Cramp, of the Electrical Engineering Department of the same University, for his wise advice in avoiding certain mechanical difficulties incidental to high speed of rotation.

Finally, I must record my gratitude to Professor W. S. Boulton, who, in spite of heavy pressure of his own work, has kindly read through a large part of my manuscripts with many helpful critical remarks. Shortcomings in the sifting and arrangement of material and possible errors are, however, all mine. As one who often has to work under adverse conditions, I should like to mention especially the moral encouragement which I have received from Professor Boulton in carrying on geological research during my college days and ever since.

As the preparation of my manuscripts drew to an end there came the sad news of the loss of a friend and highly valued colleague, Dr. V. K. Ting. It is perhaps not out of place if I take this opportunity to pay a tribute to this man who worked so loyally for the development of geological science in China.

J. S. L.

PUBLISHERS' NOTE

ARRANGEMENTS for the publication of this book were made while Professor Lee was lecturing in England in 1935. In 1936 he was recalled to China. Before he left England he placed in our hands the bulk of his Manuscript, the remainder being forwarded later. Owing to conditions which have since prevailed in China difficulties of communication between the Author and ourselves have caused serious delays.

To expedite the publication of the book, Dr. H. Dighton Thomas, who had undertaken to read the proofs, did much additional work in connection with the bibliographies, arranging for illustrations, and in dealing with numerous queries, which arose from time to time. We and the Author are indebted to him for all he has done in helping to make the publication of the book possible this year.

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PART I

CHAPTER I

NATURAL PROVINCES OF CHINA

THE physical features of a country represent the sum total of the constructive, deformative and erosive processes that have operated in that country throughout geological time. Surface expression of the physical features often affords useful landmarks for tracing out the evolution of such features. No apology is therefore needed for dealing with the outline of the physical geography of China before we proceed to inquire into its geological history. This procedure seems all the more natural, and perhaps necessary, when we realize that the physical evolution of China has been largely based on a framework that was already laid down in Pre-Cambrian times. The existing features, though they came into existence at much later dates, conform in their general arrangement with that ancient framework.

As viewed in its present relief, China embraces an expanse of land-mass in eastern Asia which half encircles the stupendous massif of Tibet, or " the roof of the world ", forming a staircase, as it were, that generally steps down towards the shelf-seas bordering the Pacific. The staircase does not, however, follow exactly the semi-circular arrangement, but is warped, distorted, shattered and sculptured according to a definite plan. As the stairs recede from the central plateau, their trend markedly departs from the shape of the nuclear platform. A decisive step can be traced across China from the north-east to the south-west consisting of the Great Khingan, the Taihang Range and the eastern border of the Kweichow Plateau. This is followed on the

east by a belt of depression covering the Sungari-Liaoho Valley, the great plain of North China and the Central Yangtze Basin. Further east, this depressed area is followed by the notably elevated land-masses of the South-Eastern Highlands of Manchuria and Shantung and of the south-eastern coastal belt embracing the area of southern Chekiang, Fukien and north-eastern Kuangtung.

Across these stretches of elevated and depressed areas are laid, at intervals, mountain ranges or watersheds that run approximately from west to east. Through these mighty ranges China is divided into several latitudinal segments, each of which, speaking generally, becomes more elevated compared with the next one to the south. The northernmost of the west-east ranges within China is the Inshan Range separating Mongolia from northern China. The next to the south is the Tsinling Range forming the natural divide between northern China, or the drainage basin of the Huangho, and the Yangtze Valley. The Nanling Range is the southernmost representative of this group of ranges and separates the valleys of the Sikiang, Peikiang and Tungkiang from the drainage basin of the Yangtze. It is these ranges, together with the Tibetan Plateau standing on the west, that have forced all the mighty rivers of China to flow from the west to the east. It is also these ranges that have naturally sharpened the climatic contrasts and regional differences in other geographical conditions, against which the Chinese have struggled for their unity during historical times through the binding influence of a distinctive culture. Having this broad framework in view, we now proceed to consider the several physiographical units of China, including the adjoining areas.

1. Tibetan Plateau

The pear-shaped mass of Tibet forms a vast plateau over 5,000 m. in average altitude. The whole plateau is surrounded by highly folded mountain ranges on all sides, and is itself traversed by long rows of mountains having their peaks falling in a curved alignment from west to east. Some of the aligned mountain masses well deserve to be

treated as mountain ranges in the ordinary geographical sense. Their geological structure is, however, still ill-understood in most cases. In the northern part of the plateau the ranges run more nearly east-west; but in the southern part the dominant ranges generally follow the Himalayan curve.

The northern border of the plateau is defined by the Kuenlun Range forming a rather sharp step by which the plateau descends to the Tarim and Tsaidam Basins on the north. Several ranges appear on the southern side of the

FIG. 2. A general view looking westward of the border of the Tibetan Plateau. (By courtesy of DR. ARNOLD HEIM.)

Kuenlun generally running parallel to the latter. Two of these appear to be quite impressive and persistent in their east-west trend. The northern one is the Kokoshili Mountain, which is probably continued farther east by the Bayen Kara Mountain slightly turned to the south of east. The southern one, even more dominating, is named the Buka Magna Dungburg Mountain. Lesser ranges of similar trend are developed farther south.

On the east, a series of high ranges marks the foreland of the plateau. These are usually styled the "Alps of Sino-Tibet". They curve into the eastern part of the

plateau from the western part of Sikang Province and the north-western part of Yunnan, gradually changing their trend from north-north-west to north-west as they enter into the plateau. Ranges allied to these run nearly meridionally in the eastern part of Sikang and north-western Yunnan.

On the southern side, the boundary between Tibet and Himalaya is marked by three ranges partly in linear succession. The western one is the Zaskar Range with the Great Himalaya on its south-western side and the Ladakh

FIG. 3. The town of Litang on the Tibetan Plateau. (By courtesy of DR. ARNOLD HEIM.)

Range on its north-eastern side running parallel to one another. In the neighbourhood of Lake Manasarowar, the Zaskar joins the Great Himalaya, and is overtaken by the Ladakh. East of Manasarowar, the Ladakh itself marks the boundary of Tibet, extending farther east to the Nepal-Tibet watershed. Thus the eastern extension of the Ladakh, together with the Nepal-Tibet watershed, forms the central part of the southern boundary of the plateau. The eastern part of the boundary lies in the Nyenchen-tang-Lha, an imposing range running east-north-east on the northern side of the upper Brahmaputra.

Some fifty miles north of the Ladakh stands a parallel range named the Kailas, essentially a granite mountain about 20,000 feet high and twenty miles broad. To the north-east of this range and north-west of the Nyenchen-tang-Lha lies a mountainous region defined on the north by the Aling-Kangri Range. This so-called Trans-Himalayan area, about 140 miles wide in its central part, extends between the latitudes of 29° and 31° N. and longitudes 81° and 91° E., with an altitude varying from 17,500 to 19,300 feet. According to Sven Hedin, this region forms the watershed between the Indian Ocean on the south and the enclosed drainage on the north. Irregular masses of mountain dominate the area; and highly complex folding of the rocks characterizes its structure.

The northern and southern boundary ranges and the Himalaya are pressed together in the western end of the Tibetan Plateau, demonstrating the phenomenon of "scharung," or bundling of mountains, on a gigantic scale. The Hindu Kush coming from the west is squeezed into this huge bundle of mountain ranges, and is continued eastward by the famous Karakorum Range stretching into the heart of the Tibetan Plateau. Fossiliferous deposits ranging from Carboniferous to Triassic in age are folded in this mighty range. This and other facts indicate that the plateau has had a more complicated history than is usually supposed.

In spite of a continued desiccation over the whole area, large and small glaciers still exist in the high mountains, and numerous lakes occur in the lower ground. The latter are generally believed to have originated from damming up of the streams by detrital material fallen from the mountain flanks. Earth movement in recent times, however, may have played a part in the formation of some of the lakes.

2. Zongor and Tarim Basins

The province of Sinkiang, or Chinese Turkestan, is divided into two large basins by the Tienshan emerging from Central Asia. The southern, or the Tarim Basin, is largely occupied by the Takla Makan desert in its eastern part. Population tends to gather round places dotted along