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(1956~2005)

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Volume Ⅷ　Works on Activated (Diwa) Tectonics and Metallogeny Written in Foreign Language (1956 – 2005)

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Foreword

Chen Guoda(1912 – 2004) is a senior academician of the Chinese Academy of Sciences, first-degree professor, educationalist, social activist, world-famous geotectonist, metallogenist, originator of the theory of activated tectonics and metallogeny or diwa theory and founder of its international school. He occupied the following positions: Vice-Chairman of the Commission on Tectonics of Ore Deposits (CTOD), International Association of the Genesis of Ore Deposits (IAGOD), International Union of Geological Sciences (IUGS), Chairman of the Working Group 4 Tectono-Magmatic Activization (Diwa), First Director of the Department of Geology, Central-South Institute of Mining and Metallurgy (now Central South University), Vice-President of the Central-South Institute of Mining and Metallurgy, First Chairman of the Geological Society of Hunan Province, First Director of Changsha Institute of Geotectonics, Academia Sinica, Member of the Committee of Planning and Guiding of Geological Work of China, Vice-Chairman of the Geological Society of China, Deputy to the Fourth, Fifth, Seventh and Eighth National People's Congress, National Advanced Worker, Scientific-Technological Advanced Worker of All-China Colleges and Universities, Special-Class Model Worker and First Scientific-Technological Star of Hunan Province.

He engaged in research and teaching in the fields of regional geology, structural geology, metallogeny, geomorphology, seismology and pale botany for more than 70 years. According to incomplete statistics, he published more than 420 books and papers in and outside China, with more than 50 books and papers unpublished. These books and papers deal with broad contents and varied forms, contributing to both regional geotectonics and metallogeny and basic geology and new disciplines. His greatest attainment lies in founding a new geotectonic theory, diwa theory (activated tectonics and metallogeny), whinch made an outstanding contribution to the development of Earth sciences and the exploitation of natural resources and exerted a far-reaching international influence. The founding of diwa theory threw off the yoke of geosyncline-platform theory governing Earth science for nearly a hundred years, and listed as one of the greatest events in the history of science in the 20th century. After unceasing development, improvement and test by practice, diwa theory was accepted by the geological community and highly appraised, thus becoming an international school originating in China with Chen Guoda named as "the guide of first generation."

He won honour for the Chinese nation and was still more an outstanding representative of scientific-technological flowers of China.

I

Chen Guoda was born on January 22, 1912 in a poor sales clerk family in Wufuli, Xinhui County, Guangdong Province, China.

In this young ages, Chen Guoda was wise, keen on learning and fond of using his head. He often followed his father going up hill and down dale and little by little became very interested in mountains and seas. Nurtured by nature, Chen Guoda from childhood cultivated the character of probing the mysteries of mountains and rivers and the habits of realistic approach, careful investigation, diligent thinking and intensive study.

In 1925, Chen Guoda was admitted to the Xinhui First Middle School. In 1928, with his excellent results he was admitted to a preparatory course at the college of Science of Zhongshan University. After two years he was promoted to an undergraduate course and chose geology. In the university his professors were geologist Zhang Xidi, paleontologist Yue Senxun, geotectonist Li Chengshan, Swiss geotectonist A. Heim and Austrian paleontologist K. Krejci-Graf. He studied very hard, paid equal attention to theory and practice, not rested on extracurricular practice arranged by the university and often used festivals and holidays to investigate the countryside around Guangzhou City.

Chen Guoda was brim with talent. In four years at the university, he published three papers. The first paper "Geology of Xinhui County", written after investigating his home village during the summer holiday, won a bonus from the National Peiping Academy for research on geology and mineral resources. Other paper *Problem Concerning the Guangzhou Delta*, based on factual materials, boldly suggested that it is not a real delta, but a geomorphological landscape consisting of a bedrock peneplain covered by alluvium of the Pearl River flood plain and remaining bedrock hills. This paper was published in the journal "Science" (1934) edited by the China Scientific Society, and won a bonus and a gold medal from it. The third paper (graduation thesis) *Red Beds in Guangdong Province* was written during his field investigation in the Danxia Mountain, Renhua County, Guangdong Province, in which he expounded the depositional environment of the Meso-Cenozoic red beds and proposed a term "Danxia Mountain Landform". This paper and other one entitled *On the Subdivisions of the Red Beds of Southeastern China* published in English in 1938 formed the most primitive basis for him to found later diwa theory and to name "diwa region" and "diwa sedimentary layer". With new ideas and originality the paper again won a bonus from the National Peiping Academy for research on geology and mineral resources.

After graduation in 1934, Chen Guoda was selected and recommended for admission to the Geological Institute of the National Peiping Academy as a postgraduate, where he took Weng Wenhao, famous geologist and discoverer and name-maker of Mesozoic orogenic movement in China, Yanshan Movement, as his teacher, and also studied under Professor Si Xingjian, famous paleobotanist, and Professor A. W. Grabau, American geotectonist. During this period he investigated Hebei, Shandong, Shanxi and Inner Mongolia, collected numerous first-hand factual materials, and published four papers, such as *A Note on the Subaquatic Deformation in the Taiku Deposits* and *A Discussion on the Maanshan Alkaline Syenite, Jungcheng County, Shandong Province.* As a result of thorough research, he found out that the "North China Platform" designated according to the traditional geosyncline-platform theory was not in accordance with the Mesozoic orogenic structures observed by him in North China. This doubt marked the birth of a new geotectonic idea in his brain. In 1935, Chen

Guoda finished graduate study, returned to Guangzhou, occupied a position as a technician in the Guangdong and Guangxi Geological Survey and concurrently teached at the Department of Geology, Zhongshan University.

On April 1, 1936, the Lingshan area, Guangdong Province, was struck by a violent earthquake. Facing the risk of aftershocks, Chen Guoda rushed to the stricken area to make investigation and wrote a far-reaching monograph *Report on the Lingshan Earthquake, Guangdong Province*, querying the validity of the traditional theory that China is low in crustal mobility with few earthquakes. This monograph is taken by seismologists as an initiative example for earthquake researches.

In 1937, Japan committed aggressin against China and Guangzhou fell into enemy hands. Chen Guoda took up a job as a technician in the Jiangxi Geological Survey. During the War of Resistance Against Japan, he passed through many provinces in South China to investigate geology, entered the haunts of tigers and wolves, lived in dilapidated temples, ate solid food, had meals in the wind and slept in the dew. This made him to suffer from rheumatism and pulmonary tuberculosis. But he not only defeated the demon of diseases, but also carried out wide investigation of the Yanshan Movement, geology and mineral resources of Jiangxi Province and even southeastern China. During this period Chen Guoda touched a wide range of disciplines and published a lot of papers. The term "Danxia Landform" proposed in the paper *Geology of the Gongshui Valley, Jiangxi Province* and *Geology and Mineral Resources between Chongren and Yihuang* is now widely used to describe the Danxia-type red beds landforms famous for marvelous peaks, with Chen Guoda praised as one of the founders of red bed geomorphology. He also discovered a plant fossil *Neuropteris gigantea* along the Gongshui River broke throught the view on Jiangxi Province having only Permian coal series, and proved conclusively that there exists Carboniferous coal series in Jiangxi Province, thus widening the trend for seeking coal in this province.

In August 1945, Chen Guoda returned to Zhongshan University, occupying a position as head of the Department of Geology and appointed professor. In 1947, he traveled to coastal Guangdong Province to study the coast geomorphology of China. In the papers *Elevated Wave-cut Benches near Guangzhou and the Origin of the Compound Shoreline of Guangdong Province* and *The Coastline Problem of China*, he corrected with convincing arguments the prevailing simple conclusion made by German geologist Richthofen on China's coastline elevated in the south but sunk in the north, and proposed a new judgment on the coastline originating as a compound from block-faulting differentiated elevation and subsidence. It is of more far-reaching significance that he gained facts about active recent (neotectonic) crustal movement in eastern China. Scientific practice of Chen Guoda during this period and scientific accumulation lasting for nearly 20 years proved that from the Mesozoic "Yanshan Movement" to the Cenozoic and until to modern neotectonic movement, a wide area manifested itself in a high crustal mobility. Liberation in academic thought removed major obstacles to initiating theoretical geotectonic exploration and study by "inheritance and innovation", forming a basis for him later to establish the "theory of platform activation". This is the period of pregnancy.

In 1948, Chen Guoda investigated oil shale in Maoming, Guangdong Province, wrote the pa-

pers Notes on Oil Shale in Guangdong and *Short Notes on Oil Shale of China*, in which he fixed great reserves of oil shale and provided the earliest reliable basis for developing oil shale after the liberation. In 1949, Chen Guoda read out a paper entitled *Exploitation of Oil Shale in Southern Guangdong* at a symposium held by the Association of 12 Scientific Organizations in Guangzhou. This paper not only aroused interest of many geologists, but also drew high attention of government officials to mineral development.

In 1951, he was appointed by the Central People's Government as a member of the Committee of Planning and Guiding of Geological Work of China.

In 1952, China made adjustment in the distribution of universities and colleges. With the incorporation of the Department of Geology of Zhongshan University into Central-South Institute of Mining and Metallurgy, Chen Guoda was transferred to Central-South Institute of Mining and Metallurgy and appointed Head of the Department of Geology, Chief of the Department of Scientific Research, Vice-President and Academic Advisor. From then on he concentrated his major effort on the "superstructure" of Earth science—solving the problem on crustal evolution and motion in geotectonics. He systematically rearranged factual materials and achievements accumulated in many years from his field investigation, and published in *Acta Geologica Sinica* a paper *Examples of Activated Region in the "Chinese Platform" with Special Reference to the "Cathaysia" Problem*, challenging the geosyncline-platform theory proposed by American and Austrian scholars and prevailing in the world for more than one hundred years. As a result of sublation and critical inheritance, he proposed the theory of platform activation. This is the initial founding of diwa theory, marking the birth of diwa theory in China. This year he joined the Communist Party, elected First Chairman of the Geological Society of Hunan Province and Vice-Chairman of the Hunan Province Association of Science and Technology. In January 1956, he attended as an observer the Second Session of the National Political Consultative Conference, kindly received at Zhongnanhai by Chairman Mao and Premier Zhou Enlai.

1956 ~ 1960 is an important period of development of diwa theory, when he together with Academician Yu. A. Kosygin investigated the tectonic structures of "activated platforms" in Hunan, Jiangxi, Guangdong, Fujian and Zhejiang Provinces, and thereafter published more than twenty papers on diwa theory, such as *Metallogenic Analysis of Activated Regions in China*, *How to Identify Activated Platforms*, *The Third Basic Tectonic Element of the Earth's Crust—the Diwa (Geodepression) Region*, *The Third Structural Layer of the Diwa Region—the Diwa Sedimentary Layer*, *A New Criterion for the Classification of Tectonic Regions—Construction* and *Theory of Progression with Transformation between Mobile and Stable Regions—A New Recognition of the General Regularity in Crustal development*, and also published a book *Theory of Platform Activation and Its Significance in Searching for Ores*. Up to this point the embryo of the earliest theoretical construction of diwa theory was formed. In 1965, Chen Guoda by use of a pluralistic concept published a paper *Diwa (Geodepression) Region—A New-Type Postplatform Mobile Region*, in which he gave a systematic description of the basis of the theory established by him—diwa region. This achievement won a prize on natural sciences from the Chinese Academy of Sciences.

In 1961, the State Council approved to set up a special institute, Central-South Institute of Geotectonics and Geochemistry, Academia Sinica, with Chen Guoda appointed Director.

In 1966, Xingtai, Hebei Province, was struck by a violent earthquake, Arranged by the State Council, Chen Guoda led his assistants to the stricken area to investigate the earthquake. He also undertook to do earthquake intensity regionalization in the Anyang area and to identify earthquake intensity along the Chengdu-Kunming railway.

During the Great Cultural Revolution, Central-South Institute of Geotectonics and Geochemistry was cancelled. All kinds of obstructions did not stop his academic thinking. He still worked untiringly and finished the manuscript of the book *Methods of Metallotectonic Researches*. In 1975, the cancelled institute was resumed to be named Hunan Institute of Geotectonics with Chen Guoda appointed again Director. In 1977, he set up a journal "Geotectonica et Metallogenia" and himself held office as Editor-in-Chief.

Along with the end of the Great Cultural Revolution and the convening of the National Scientific Conference in 1978, Chen Guoda greeted the spring of life in the course of his scientific research, and diwa theory founded by him entered a stage of overall expansion. In 1978, his book *Methods of Metallotectonic Researches* was published, and his *Tectonic Map of China* (1∶4 000 000) and *Geotectonic Outlines of China* won two prizes from the National Scientific Conference. In the same year, Hunan Institute of Geotectonics turned over to the Chinese Academy of Sciences, renamed Changsha Institute of Geotectonics, Academia Sinica, and Chen Guoda held office first as Director and then Honorary Director. After that, his paper *The Third Tectonic Element of Continental Crust—Diwa Region* won a second prize for national natural sciences, and other books and papers related to diwa theory won separately prizes at provincial and ministerial levels.

In 1979, Chen Guoda was elected Vice-Chairman of the Geological Society of China. In 1980, he was elected Academician of the Chinese Academy of Sciences. In the same year he was invited to give lectures in Frankfurt University, Germany. This was a beginning for him to propagate diwa theory abroad. Then he attended on behalf of China the 26th International Geological Congress held in Paris, read out a paper *Diwa* (*Geodepression*) *Theory and Its Practical Significance*, elected Vice-Chairman of the Commission on Tectonics of Ore Deposits, International Association on the Genesis of Ore Deposits, International Union of Geological Sciences, and appointed advisory member of the Editorial Board of the Journal "Global Tectonics and Metallogeny". After the congress, he investigated the tectonic structures of the Baltic activated (diwa) region, the Kiruna iron ore deposit in Sweden and Cu-Zn sulfide deposits in Finland. In 1981 – 1989, he was one after another invited to deliver lectures in four institutes and nine universities in USA, such as New York University, Columbia University, Colorado University, American University and Texas University. He also investigated the western America activated (diwa) region, Rio Grande Rift Valley, Colorado Plateau and Tularasa diwa basin.

In 1982, as a first Chinese scientist invited after suspension of scientific relation between China and USSR, Chen Guoda was invited to visit USSR and give lectures in Moscow University, All-U-

nion Geological Institute and Institute of Precambrian Geology and Geochronology AS, USSR and Liningrad Institute of Mining. He was invited to attend the 6th Quadrennial IAGOD Symposium held in Tbilisi, took the chair and gave a specially invited lecture *Polygenetic Compound Ore Deposits and Their Origin in the Context of Regularities in Crustal Evolution*. This new concept of polygenetic compound ore deposits proposed by him was developed later into an important constituent part of the theory of progressive metallogenesis. After the symposium he investigated the geology of Central and West Asia. This visit of Chen Guoda was considered a milestone in China-USSR "scientific diplomacy." In the same year he was approved by the State Council one of the first tutors of candidates for Ph. D. and then a tutor of postdoctoral researchers and visiting scholars.

In 1983, Chen Guoda presided over the First All-China Symposium on Tectonogeochemistry (in Changsha) and gave a lecture *Some Problems Concerning Tectonogeochemistry*. Proposed by Chen Guoda in 1961 and tested by long-term practice, this cross discipline became a newly added part of the theoretical construction of diwa theory. In June 1983, he traveled to Wuling Range, Zhangjiajie to investigate quartz sandstone peak-forest landscape, engaged as a scientific advisor for the Wulingyun National Scenery Area. In September he was invited by Japanese geologists to visit Japan and gave lectures in several universities and institutes. In Japan he investigated the Medium Tectonic Line, collapse structures and so on.

In July 1982, he was invited to visit Yugoslavia and give lectures. He traveled to Serbia, Bosnia-Herzegovena and Macedonia to see the activated (diwa) structures of these areas. In September 1984, specially invited by the Organizing Committee of the 27th International Geological Congress, he attended the congress, at which he gave a specially invited lecture entitled *Geotectonic Nature of the Fen-Wei Graben—a Rift-Type Diwa (Geodepression) System*. At the opening and closing ceremonies, he was arranged to be seated in the front row on the rostrum. He was the first Chinese scientist who was accorded such a courteous reception since the founding of the International Geological Congress.

In 1986, he was invited to give lectures in Hong Kong and accorded a warm welcome. In September 1986 he presided over the First All-China Symposium on Diwa Tectonics and Metallogeny. Deng Liqun, Secretary of the Secretariat of the Central Committee of the Communist Party of China, and other leaders attended the symposium to extend greetings. The symposium ended in the founding of the Chinese Research Society of Diwa Theory (preparatory), with Chen Guoda elected President. In 1987, he attended separately the Beijing Meeting of the International Lithosphere and the China-USSR Symposium on Marine Geology. A series of his academic exchanges and lectures further extended diwa theory (theory of activated tectonics and metallogeny) to the world.

In 1988, he presided over the First International Symposium on Diwa Tectonics and Metallogeny. At the Symposium delegates from various countries proposed to set up an international research center for diwa tectonics and metallogeny, with the center established in Changsha, China and Chen Guoda appointed Chairman. In 1989, he led the Chinese delegation of scientists to visit Mongolia, where they made academic exchanges and investigated the activated (diwa) structures and famous

copper mines of Mongolia. Afterwards, Russian and Mongolian Sub-centers were established in 1992 and 1992, respectively. In 1989, the English edition of the journal "Geotectonica et Metallogenia" was issued, with Chen Guoda appointed Editor-in-Chief.

In the 1990's, research on the theory of activated (diwa) tectonics and metallogeny became part of the international cooperation organized and planned by IUGS, On August 14, 1990, the IAGOD Council decided to set up WG4: Tectono-Magmatic Activization (Diwa) under the Commission on Tectonics of Ore Deposits, with Chen Guoda appointed Chairman. This is the first international academic organization named after the theory founded by a Chinese scholar. In the same year, at the 15th International Symposium on the History of Geological Sciences, he presented a paper *Historical Significance of the Yanshan Movement*. He emphasized from a global angle the objective geological record of Mesozoic orogenic movement, which played an important role and had a far-reaching significance for research on tectonics and metallogeny of continents.

In 1991, Chen Guoda and A. L. Yanshin together presided over the Second International Symposium on Diwa Tectonics and Metallogeny held in USSR. Then the IGCP-361 Project "Metallogeny of Mesozoic Activization Zones of East Asia" was approved by the IGCP Executive Committee. Chen Guoda held the post of first vice-chairman. He also together with Soviet and Japanese geologists accomplished the *Volcano-Tectonic Map of East Asia* (1∶3 000 000). Thus diwa theory was further brought into international cooperation.

Chen Guoda initiated and emphasized the combination of geotectonic with metallogenic researches. From the 1980's onwards, he proposed from a metallogenic angle the theory of polygenetic compound ore deposits, further enriched the contents of diwa theory and metallogeny, and by using the theory instructed colleagues of Changsha Institutes of Geotectonics, Academia Sinica and Department of Geology, Central-South University, in taking on tens of national, ministrial and provincial projects. They obtained a lot of scientific research achievements and won successively prizes at national, ministrial and provincial levels.

From 1990 until to his death in April 2004, Chen Guoda made a systematical summary and an overall extension of diwa theory founded by him, dealing with discipline category, research scope and direction, research aim and methods. He wrote a book *Diwa Theory—Activated Tectonics and Metallogeny* published in Chinese and English in 1996 and 2000, respectively. This book is a comprehensive monograph clarifying the theoretical system of activated (diwa) tectonics and metallogeny for the geoscience community. In 1991, he proposed to set up historistic-causationist integrative geotectonics, putting the theoretical system of activated tectonics and metallogeny established by him into a higher level at a scale of global tectonics. In 1992, he published in Chinese and English a paper *Historistic-Causationist Geotectonics*, proposing to combine the evolution and motion of lithospheric blocks (crustobodies) of all continents and oceans for united study by using a historical-dynamic integrated analysis method, and thus founded historistic-causationist geotectonics. This is the continued innovation of diwa theory established by him. In 1994, he edited and published *Crustobody Geotectonic Map of Asian Continent and Adjacent Seas* (1∶8 000 000), which won a second prize for

natural sciences from the Chinese Academy of Sciences. In 1996, he submitted a paper, *Crustobody Geotectonics—A New Concept in Integrative Geotectonics* to the 30th International Geological Congress. In 1998, a book *Crustobody Geotectonics of Asian Continent and Adjacent Seas* was published with him as Editor-in-Chief. Three events occurring in the process of evolution-motion of crustobodies in Asia proposed in the book as an original idea were praised by academic circles as three projects on the front of Earth science. This achievement won a candidate prize for National Book Prizes and a Second Scientific-Technological Advances (Scientific-Technological Books) Prize. At this stage of extension and reinnovation of diwa theory, he still published a few books and papers until his death in 2004, such as *Necessity for Studying the Tectonics and Metallogeny of Asian Continent and Adjacent Seas by Way of Thinking Independently and Innovating on One's Own* and *Historical-Dynamic Tectonic Differentiation of the Eastern and Western Parts of the Central Crustobody of Asian Continent and Its Significance.*

During a half century beginning in 1956, diwa theory (activated tectonics and metallogeny) founded by Chen Guoda went through several stages: from initial founding to enriching-development to extension and reinnovation, and underwent a long process of development. First the world connected to it and then it connected to the world. Chen Guoda devoted the energies of his last 20 years and more to pushing he original and innovative diwa theory to the world and to promoting international cooperation. He gave his all till his heart stops beating for development of Earth science, for vitalization of science and technology of China, and extension of its influence in the world.

Ⅱ

Diwa Theory, when it was proposed, met with acceptance of foreign geologists. Many authors wrote papers or books, systematically quoting and introducing in detail this theory. In 1959, A. L. Yanshin first translated the Chinese term "diwa" into a Russian term "дива". Afterwards, A. D. Shcheglov, V. I. Kazansky, F. F. M. Almeida, Yukinori Fujita and other scholars also successively quoted it. The term "diwa region" or "activated region" was included in the *Geological Dictionary* of USSK (1978), *dictionary of Earth Sciences* of Japan (1971) and *Lexicon* and *Dictionary of earth Sciences* of China, In fact, "diwa region" is not a phenomenon peculiar only to China, it exists everywhere in the world. For example, the book *Geology of Korea* (1968) stated that the geological development of Korea had entered a diwa stage since the Triassic, and the period of Mesozoic metallogenesis played an important role in the formation of ore in Korea. I. N. Tomson in his book *Metallogenic Analysis in Regions of Activization* pointed out: "The development of modern geology depends upon two new concepts, plate tectonics and the third type of the development of crustal structure determined by the process of tectono-magmatic activization. These two scientific directions have become a basis for reexamining metallogenic theories." E. A. Alexandrov in reviewing A. D. Shcheglov's book *Metallogeny of regions of Autonomous Activization* in *Economic Geology* emphasized that "Credit is given to Chen Guoda of China . . ." A. D. Shcheglov in lectures delivered by him during his visit to Changsha Institute of Geotectonics and Nanjing University highly appraised the success a-

chieved by China in the fields of tectonics and metallogeny, pointed out that "the concept of tectono-magmatic activization of USSR is based on diwa theory", "Chen Guoda is a guide of first generation to our theory" and "Professor Chen Guoda is a force supporting the concept of tectono-magmatic activization in the world." He again and again stressed that "founded by Chen Guoda, diwa theory originated in China, but it is applicable not only to China, it has a global significance."

In addition, diwa theory was also highly effective in directing mineral prospecting. Outside of China, the former USSR first applied the new concept of platform "activated region" to ore-seeking practice. Soviet geologists used the theory of diwa found rich deposits of tungsten and tin in the Transbaikalian area considered barren of ore. Tin deposits in the northern part of Brazil, fluorite, mercury and antimony deposits in Australia and many metallic ore deposits in Czech, France and Canada were all discovered by use of diwa theory. At the Scientific Conference on Mineral Resources and Geological Survey held in St. Petersburg, Russia, particular stress was laid on the metallogeny of activated (diwa) structures. Academician Petlovich pointed out that "Mesozoic tectonic activization is a global phenomenon, many important mineral deposits are related to it. Taking uranium deposits as an example, all supergiant uranium deposits on a world scale ... occur in diwa structures, and thus metallogenic studies of diwa structures is of universal significance."

In China there are still more examples of success in mineral prospecting by use of diwa theory. Based on the tectonic peculiarities of diwa regions, petroleum geologists found large oil fields in Xinjiang and northern China. The first discovery of primary gold deposits in Altai Mountain, Xinjiang, made the area promising in gold prospecting. Gold ore zones were also found in the Baoban area, Hainan Province. Large gibbsite deposits were first found in Guangxi. The Laochang lead-zinc-copper deposits and Gejiu tin deposits in Yunnan Province, the Xiangxi gold deposits, Xiangdong tungsten deposits and Huayuan lead-zinc deposits in Hunan Province, the Fankou lead-zinc deposits in Guangdong Province, the Daye iron deposits in Hubei Province, the Tongling copper deposits in Anhui Province, the Jinchuan nickel deposits in Gansu Province and other large metallic ore deposits were known by using diwa theory to contain new hidden mineral resources at depth and outside. Moreover, diwa theory also played an important role in earthquake prediction and site choice for the Wujiangxi and Zhexi hydroelectric stations. These facts fully reflect the distinguishing feature of diwa theory: theory combining with practice and innovation paralleling with extension.

As this new theory of crustal evolution played a pioneering role in geotectonics, it was cited as one of the great events in the history of science (Dictionary of History of Science and Technology, Japan, 1983). International academic exchanges, cooperation, lecturing and visits made by Chen Guoda from the end of the 1980's to the beginning of the 21st century not only extended diwa theory (activated tectonics and metallogeny) to the geoscience communities of various countries, enlarging the influence of this innovative theory in the world, but also demonstrated diligence and intelligence of the Chinese people and scientific researchers to the world, winning honour for the Chinese nation. Senior Academician Ye Lianjun in his paper *Cheriching Geotectonist Chen Guoda* wrote in praise of him: "Academician Chen Guoda is a geoscientist respected by the international geoscience commu-

nity"; "Academician Chen Guoda fought all his life for the advance and development of the geological cause of China"; "the theory of the third tectonic element, diwa theory, advanced by him was acknowledged by the international geotectonic community as a newest geotectonic theory, winning honour for the geological community of China." In spite of poor health in his later years, he treated time as if it were gold, and uninterruptedly strode forward. The concept of crustobody geotectonics proposed by him in 1991, i. e. a new scientific idea combining evolution of the lithosphere with its motion for united study represents a new exploration target in the geoscience community.

Chen Guoda made an outstanding contribution to science and thus earned favourable comment. He held more than 20 posts in the fields of science and technology, elected a deputy to the First, Second and Third Hunan Province People's Congress and to the Fourth, Firth, Sixth, Seventh and eighth National People's Congress. In 1989, he was chosen as a special-class model worker of Hunan Province and a national advanced worker. From 1988 to 1989, he was chosen into American books "A Collection of International Distinguished Leaders" and "Dictionary of International Famous Persons" and a British book "Five Thousand World Famous Persons". In 1990, he was conferred the title of an advanced worker of All-China institutions of higher learning and in 1966 chosen as a first scientific-technological star. In 2000, the Hunan Province Association of Science and Technology organized to sculpture two bronze statues, which stand at the campus of Central South University and in Changsha Institute of Geotectonics, respectively, to express reverence for this great academic master.

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Chen Guoda was a Chinese scientist born and brought up in the locality. His brilliant achievements in scientific cause were closely related to his correct approach in academic pursuits and scientific methods. Four words "To persevere, to brave, to be strict and to be diligent" is an institute spirit formulated by him for Changsha Institute of Geotectonics as well as his academic motto and experience summary in his scientific exploration during more half a century.

Chen Guoda thought that a scientist must, first of all, have strong aspirations to scale new height in science, and keep in any situation a firm perseverance. Just such aspirations made him in the "ten chaotic years" withstand pressure from many sides, and did not break off working. Whatever happens, he always kept calm.

He constantly exhorted his students to dare to innovate and have a consciousness to outstrip predecessors. When working, one must be brave, but making investigation and doing experiment, he should be scrupulous about every detail. Discovery and invention need to be published promptly, and modesty is necessary when facing success.

He believed that a serious, strict and tight style of work and a steady, realistic and honest character are a key to success. He particularly placed stress on methods of thinking. A considerable amount of his papers was permeated with such a thought of materialist dialectics. When young, he was diligent in field investigation. Even in old ages, he still persevered at the forefront of scientific

research, with his footprints extending over whole China and famous mines of Asia, Europe and America.

He believed that scientific morality and work ethic are one of the most basic and indispensable qualities. A qualified scientist must have noble morals, good qualities and hardworking and thrifty habits. Depending on such habits, he was diligent in writing in his career as a geologist more than 70 years, having published over 420 books and papers. Even when he was over eighty years old, he learned to use computers to write, chosen as one of a hundred Chinese scientists with publications having the strongest international influence.

He was learned and versatile and had a good grounding in literature. After work on probing the mysteries of nature, he wrote nearly a hundred scientific poems, simple in style and far-reaching in meaning. A book *Selected Poems of Chen Guoda* was published in 1995, with second edition coming off the press in 1998.

Chen Guoda had a mind as open as a valley, cultivated people of ability and had students everywhere. Besides educating thousands of undergraduates, since the 1960's he had fostered more than one hundred masters, more than 50 doctors and several ten postdoctoral fellows, many of which already became scientific flowers at the front of geological research and production.

Chen Guoda was strict with himself and lenient towards others. He hated bitterly people being generous at the nation's expense and seeking private gain at public expense. He led a simple life. In his room there was not even a decent furniture besides the endless array of books. When giving lessons he begrudged throwing away the remaining chalk stubs, and when writing he even turned over used envelops to use them again. Nevertheless, in order to promote the development of diwa theory and to encourage successors, he generously donated his money awards, contribution fees and other income to set up "Diwa Theory Reward Fund", encouraging those scientists who theoretically developed diwa theory or practically made a great contribution to it. Since founded in 1983, the fund has issued awards 11 times, and more than 80 geologists won such special honours. In addition, he also wrote prefaces to books of a few authors, encouraging young geologists to goall out to make themselves useful.

Chen Guoda used time as if it were gold. Even when he reached old ages and suffered from hypertension and coronary heart disease, he still worked without holidays. In spite of having difficulty getting about, he persisted in writing selflessly.

After 1996, he successively published a few books such as *Diwa Theory—Activated Tectonics and Metallogeny*, *Crustobody Geotectonics of Asian Continent and Adjacent Seas*, *Activated Tectono-Metallogeny* and *Crustobody Tectono-Metallogeny of Copper-Polymetallic Deposits in Yunnan Province* and nearly 10 papers. At a few hours before his death, he still wrote words of encouragement for the magazine *Education Heaven and Earth* and discussed academic problems with his assistants and students by telephone.

On April 8, 04:23, 2004, Chen Guoda died of myocardial infarction in Changsha at the age of 93.

Ⅳ

Based on the wishes of Chen Guoda before his death and entrusted by his relatives after his death, two units in which Chen Guoda worked, Central South University and Changsha Institute of Geotectonics, Academia Sinica, took the lead to organize an editorial and publishing board composed of academicians, specialists and scholars for editing and publishing *The Complete Works of Cheng Guoda*. Entrusted by Chen Guoda's relatives, Central South University Press is in charge of concrete matters relating to publication. Chen Guoda's publications are plentiful. In order to correct and publish materials related to diwa theory, the Editorial and Publishing Board of "The Complete Works of Chen Guoda" has collected over three years more than 450 publications with Chen Guoda as sole or first author (including unpublished). According to the principle of volume division by contents in combination with time determined by some members of the Editorial and Publishing Board at a forum, the complete works were divided into nine volumes, with one volume containing about a million words.

Volume Ⅰ: The pregnancy with Diwa Theory (Investigation of the Regional Geology and Mineral Resources of China) (in Chinese and English from 1932 to 1955)

Volume Ⅱ: The Initial Founding of Diwa Theory (Activated Tectonics and Metallogeny) (from 1956 to 1960)

Volume Ⅲ: The Enriching of Diwa Theory (Activated Tectonics and Metallogeny) (from 1960 to 1977)

Volume Ⅳ: The Extension of Diwa Theory (Activated Tectonics and Metallogeny) (from 1977 to 1992)

Volume Ⅴ: The Reinnovation of Diwa Theory—Historistic-Causationist Crustobody Geotectonics (from 1992 to 2005)

Volume Ⅵ: Diwa Theory—Outline on Activated Tectonics and Metallogeny Theoretic System

Volume Ⅶ: Activated Tectono-Metallogeny

Volume Ⅷ: Works on Activated (Diwa) Tectonics and Metallogeny Written in Foreign Language (1956 – 2005)

Volume Ⅸ: Scientific Thoughts and Methods, Popular Science Works and Poems.

Volume Ⅵ and Ⅶ systematically describe activated tectonics and metallogeny (Ⅰ and Ⅱ), being the summary of the world-famous diwa theory proposed by the author as a result of long-term theoretical study and scientific practice, and published in 1996 and 2004, respectively.

The Complete Works of Chen Guoda include papers, books and writing works reflecting his academic thought and fighting spirit, published before his death from the 1930's to the beginning of the 21st century. These works are all original. Textbooks (6), selected works (3), translations and works written by other authors in cooperation with Chen Guoda, apart from important contents included in the text proper, are generally put in the appendix to present them simply. In addition, the appendix also contains the following items related to Chen Guoda's activity: visits and giving lec-

tures in China and abroad, list of trained graduates (masters, doctors and postdoctorial fellows) and titles of their theses, representative projects and praises, winners of the "Diwa Theory Reward Fund" and titles of their papers, diwa theory exhibition hall, journal "Geotectonica et Metallogeny", international symposia on diwa tectonics and metallogeny and Chen Guoda's bibliography. Some important and unpublished lectures delivered in certain units are also included in the text. But other lectures, contents of which duplicate those of published papers to some extent, are included in excerpts.

Chen Guoda's works span a long time and thus they vary in form and layout. Editors of *The Complete Works of Chen Guoda* use the international standardized style, which is expressed by 1, 1.1, 1.1.1 ... followed by 1), (1), ①, A and (a)... Figures and tables in papers are numbered in singular number arrays, e.g. Figure 1, Table 1, while those in books, in double number arrays, i.e. chapter number plus figure number, e.g. Figure 2-2, Table 2-2. Figures taken originally by photomechanical process, have to be duplicated by line scanning. Large maps (e.g. Tectonic Map of China at a scale of 1∶4 000 000 and Crustobody Geotectonic Map of Asian Continent and Adjacent Seas at a scale of 1∶8 000 000) are reduced in scale. Notes are divided into two Kinds. Author's notes such as ①,② and ③ are placed beneath pages, while editor's notes are expressed by an asterisk (*) followed by footnotes (e.g. title of a book or journal, volume, number, page, time). Literature is still put after a paper or book, but adjusted to placing Chinese first and English next. Literature in the author's publications largely adopts the Harvard System Record Method, and therefore literature in Volumes 1 to 7 and 9 (in Chinese) is standardized according to this method, but that in Volume 8 (in English) still adopts the order coding system.

In order to make readers to understand the writing background, main points and significance of some important publications concerning new concepts and viewpoints proposed in the process of development of diwa theory, we, entrusted by Chen Guoda before his death, specially invited related members of the Editorial and Publishing Board to write editor's explanatory notes for every volume to indicate the number of publications in each volume, and the historical background, main points and influence of important publications. Titles of important publications in the contents of every volume are printed in boldface for attracting attention. Finally, entrusted by Chen Guoda before his death, we have also revised printing errors and unified special terms.

We are grateful to Changsha Institute of Geotectonics, Academia Sinica, College of Geoscience and Environment Engineering, Central South University and Chen Guoda's relatives for their support and help in collecting materials. We thank Beijing National Library, China Geological Library, All-China Geological Reference Hall, Geological Society of China, Geological Society of Hunan Province, Hunan Province Library, Guangzhou Zhongshan Library, Zhongshan University Library, Central South University Archives and Library, College of Geoscience and Environment Engineering Reference Hall of Central South University for their help.

We express thanks and sincere appreciation to Academicians Ye Lianjun, Sun Shu, Zhai Yusheng; Huang Peiyun, Huang Boyun and He Jishan for their warm encouragement and support, to

some units and individuals for their financial support (*Vide* list of financial supporters), to Academician Zhou Guangzhao, honorary chairman of China Association of Science and Technology, and Academician Huang boyun, vice-chairman of China Association of Science and Technology, president of Central South University, for writing an inscription, and to Academician He Jishan, Chairman of Hunan Province Association of Science and Technology for writing an inscription and the title of the complete works.

The foreword is written by Chen Guoda's administrative secretaries and academic assistants working in Changsha Institute of Geotectonics, Academia Sinica and Central South University. We have solicited opinions about it from all members of the Editorial and Publishing Board. The foreword has been examined and approved finally by academicians, specialists and scholars. The general preface to *The Complete Works of Chen Guoda* (acting for the author's preface), as decided through consultation form members of the Editorial and Publishing Board at a forum, takes a paper "Thinking Independently and Innovating on One's Own" (Academician Working Bureau, Chinese Academy of Sciences: Road to Science, Shanghai Education Press, 2005), being placed before each volume.

With a feeling of great reverence for Chen Guoda we have collected, rearranged and edited his publications, very pleased to see *The Complete Works of Chen Guoda*, which is the fruit of our painstaking labour, coming off the press. The reason is that these publications are not only the historical record and scientific summation of the geological undertaking and the founding, development and updating of diwa theory (activated tectonics and metallogeny) done by Chen Guoda all his life, but also a valuable scientific and cultural heritage left behind for the Chinese nation and even the international geoscience community. The geological research and education of Chen Guoda spanned a long time and experienced three turbulent stages, the War of Resistance Against Japan, the eve of the liberation and the "Great Cultural Revolution". Therefore, collecting and rearranging materials met with arduousness and difficulty. Mistakes and omissions are hard to avoid. Will you be kind enough to correct and improve these works? We will in due course again edit and publish those works of Chen Guoda missing from *The Complete Works of Chen Guoda*.

Editorial and Publishing Board of
The complete Works of Chen Guoda
August 25,2007

Thinking Independently and Innovating on One's Own (Acting for the Author's Preface)

Ye Xiezeng, a scholar in the Qing Dynasty, said: "Only by knowing can we distinguish clearly between right and wrong, and only by distinguishing clearly between right and wrong can we decide to accept or reject. There are cases in which one follows the footprints of the ancients, and there are also cases in which one does not follow the footprints of the moderns." This admonition, as applied today to guiding us in scientific research, in my understanding, means that we should accurately understand the theories of predecessors, draw a clear distinction between the dross and essence, based on critical inheritance develop what is useful and discard what is not, and think independently and innovate on our own in accord with the result of our own investigation and experiment. It plays a key role in my scientific career all my life.

Beginning from my youth, I has been very keen on thinking and verifying. In regard to some academic theories or viewpoints open to doubt, I often think of trying to test them first, and then believe and accept them after knowing that they are well-founded. Just such a custom has benefited me in my later tectonic research.

Since the late 19th century, in geology the most popular theory concerning the evolution of the earth's crust has been the "geosyncline-platform theory" proposed successively by American scholars J. Hall (1859) and J. D. Dana (1873) and Austrian scholar E. Suess (1885). Over the last one hundred years, this theory has dominated the whole earth science, believed to be a doubtless truth. According to this theory, most of eastern China has long been classified as a platform region named "Chinese platform." On the basis of my own long-term investigation and repeated study, in combination with the analysis of numerous data left by predecessors, I found that before the mid-Mesozoic (200 million years ago) this region actually experienced a geosyncline-platform stage, as supposed by the advocates of the geosyncline-platform theory. But since the mid-Mesozoic, a new situation has arisen early or late on this famous "Chinese platform": Crustal movement became intense, characterized by remarkable horizontal movement, orogenic process took place, and fractures, folds, overthrusts and nappes appeared quite a lot. They made up tectonic structures and landforms with a sharp contrast, i. e., high mountains alternated with deep valleys, forming a basin-range pattern. At the same time, large-scale magmatic and metamorphic activities occurred, bringing about mineral deposits rich in nonferrous metals. Ore deposits—there is no lack of giant and ultragiant ones—of the Nanling Mountain Range known as "the home of nonferrous metals" were formed just in this period. At present this region is undergoing intense neotectonic movement and frequent seismic activity. Some place, such as Wudalianchi in Heilongjiang Province, witnessed volcanic eruption even 200 years ago. All these features are not proper characteristics of a platform region as a stable region

(craton), but typical marks of a mobile region (orogenic belt). The geosyncline-platform theory cannot explain this phenomenon, and thus hinders the correct understanding of the tectonic nature of this region. As a result, we are unable to rationally use and remake nature, effectively seek mineral resources and wipe out natural hazards.

The purpose of scientific research is to accurately understand nature, to grasp natural laws, to give service to production, to develop the national economy and to work for the well-being of mankind. If we can solve the problem about the tectonic nature of eastern China at the present stage, all-sides know the history of crustal development of this region, thus conducive to the understanding of the distinguishing features and temporal-spatial distribution pattern of mineral deposits hidden in it to more effectively guide us in mineral prospecting, we can make a great contribution to socialist construction in China and development of geology in the world. For this purpose, I have carried out field investigation and thematic research in related areas of China and collected first-hand materials. Based on referring to data of predecessors, I decided on this research project in 1954, and integrating with education carried out research. After further supplementary investigation, material collection, systematizing, induction, comparision, analysis and reasoning for two years, I published my first paper in 1956. This is *Examples of activated region in the "Chinese platform" with special reference to the "Cathaysia" problem*, called by geologists as the mark of the birth of diwa theory. This paper proposed the use of the term "activated region" (renamed as "diwa region" in 1959) to describe the tectonic nature of southeastern China at the present stage since the mid-Mesozoic. Afterwards, I continued to add arguments and make a lot of revisions, and thus formed a comparatively complete theoretical system. After seeking and searching for decades of years, this system advanced from pregnancy to birth, progressively took shape and unceasingly developed. Today, diwa theory has evolved from a relatively simple concept of diwa structure (including geodome mountain and diwa basin) used to depict the tectonic features of the continental crust represented by southeastern China and confined to the study of the structures of continental crust, especially intracontinental orogenic belts, into a theoretical system, which integrates the evolution of lithospheric blocks with their motion, has five constituents and a few derivative disciplines, and deals with both continents and oceans.

The above-mentioned result of research has withstood the test of time for more than 30 years and practical examination by geologists at home and abroad, and has proved to be of the following value and significance.

(1) The concept of diwa (activated) region suggests that eastern China in tectonic regime is a mobile region (orogenic belt). In tectonic nature this mobile region is contrary to a platform region, and also differs in terms of distinguishing features from a geosynclinal region. It is a tectonic element of another mobile region type, named at first as "(platform) activated region" (1956). At present the terms "activated region" and "diwa region" are used as synonyms at home and abroad.

(2) Theoretically diwa theory has smashed the bonds of the traditional thought "either geosyncline or platform" regarded as truth for nearly one hundred years, and discovered in areas of conti-

nental crust a post-platform mobile region of new type, i. e., a third tectonic element of continental crust other than geosyncline and platform.

(3) The concept of diwa (activated) region originated in China, but proved by practice to be of world-wide significance.

(4) The concept shows that the process of the evolution-motion of continental crust proceeds, through mutual transformation and alternation between mobile and "stable" regions, from a simple to a complex construction, rises spirally and advances like wave.

(5) Diwa regions are of important metallogenic significance. Discovery of diwa regions made the development of metallogeny enter a new stage with addition of new contents.

As the concept of third tectonic element or diwa region is of great scientific and social significance, it has been recognized as one of the "new theories determining the development of modern geology" and "a basis for concrete prognosis" in mineral prospecting (Tomson, 1973). When reviewing the metallogenic importance of regions of autonomous activization, E. A. Alexandrov in the magazine *Economic Geology* pointed out in 1976 that credit is given to China. Diwa theory now has became an international school originating in China with the Chinese scholar as the "guide of first generation". At the first international symposium on diwa tectonics and metallogeny held in 1988, scientists from various countries made a proposal to set up an international research center for diwa tectonics and metallogeny. In 1991 and 1992, two subcenters were established in Russia and Mongolia respectively. When holding a meeting in Canada, the Council of the International Association on the Genesis of Ore Deposits decided to set up the Working Group 4: Tectono-Magmatic Activization (Diwa) under the Commission on Tectonics of Ore Deposits. In 1993, the Executive Committee of the International Geological Correlation Programme approved to establish the project on "the metallogeny of Mesozoic zones of activization (diwa) as IGCP 361, and thus the tectonic and metallogenic studies of diwa regions were brought into line with the international cooperation programme".

The reason why the result is achieved is that in the process of scientific research I pay attention to the following points.

Adopting a correct attitude towards the theories of predecessors, learning from others' strong points and innovating on one's own. We must learn modestly any scientific theories related to the field of our research to all-sides and thoroughly understand them, but should not give a total and uncritical acceptance to them. Everything has its good and bad sides, and we should only take its good side. That is to say, we must, based on concrete materials, test the original theories, affirm and inherit the part that conforms to reality, but ought to probe into the part that has not been verified or cannot withstand test, taking it as an object for selecting a topic in order to innovate. I maintain that we should respect the fruits of labour of predecessors and gain knowledge from them. However, we must not get bound by them, but seek the truth based on our own materials and thinking. As for problems unsolved by predecessors, we need to acquire confidence, to vow to adhere to our chosen course in order to get to the bottom of this matter.

Facing the national economy and maintaining close ties with production. When selecting

topics, along with the correct understanding of the objective world and the grasping of objective laws, I pay special attention to the needs of construction of the national economy. I realize that topics of greater practical significance may acquire achievements of greater social effect and economic returns, which will be easy to be valued highly and popularized, and to obtain test by practice soon and thereby to be substantiated and deepened.

Taking note of methods of research and paying equal attention to deduction and induction. Method of induction enriches the mind and makes us propose numerous hypotheses. But before proved by test, they are still hypothetical, even if they are pleasant to listen and alluring. If they look flashy and without substance, they can hardly be free from testing by practice, even though pursued for a short while. Only by laying equal stress on method of induction and method of deduction, by alternately using them and by verifying at any time the correctness of our hypothesis, can we be easy to make conclusions close to the objective reality.

Paying attention to field investigation and combining macroscopic with microscopic analysis. The reason why the theory of diwa tectonics has a certain practicality, considered to demonstrate by the use of convincing arguments that diwa region is a tectonic element of first rank equal to geosynclinal and platform regions (Shchglov, 1968) is that it benefits from such an approach. Belittling of any side will influence the quality of scientific research. In recent years geologists in some countries have looked down on field work. This wind also blows into China. It is inadvisable to do an imitation.

Stressing method of thinking and paying attention to dialectical thinking. Basic theoretic problems often involve major matters of fundamental importance in science. In the whole activity of scientific research we will get valuable guidance from the use of dialectics of nature. In the field of tectonics, formerly some geologists emphasized the study of the evolution of the earth's crust, used the method of historical analysis and put stress on vertical movement. Today, however, other geologists emphasize the study of the motion of lithospheric blocks, used the method of dynamic analysis and attach importance to horizontal movement. Both of them have strong and weak points, biased against each other. If we use dialectical thinking to integrate them, set up a discipline, historical-dynamic tectonics, and a concept of crustobody, combine the evolution of lithospheric blocks with their motion and apply the method of integrated historical-dynamic analysis for united study, emphasize their dynamic state both in time and space, i. e., integrate the viewpoint of development with the viewpoint of connection, give consideration to both time and space and attach importance to horizontal and vertical movements, we can more all-sides understand the earth, and the established theory will more effectively guide us in production. The reason why I could find diwa region, a mobile region of new type, to be the most primitive constituent of the foundation of diwa theory is that it benefits just from such a mode of thinking. Other constituents of the theory, including their entire guiding ideology and the mode of thinking, differ from the geosyncline-platform theory and plate tectonics also in this respect.

Chen Guoda

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Examples of "Activated Region" in the Chinese Platform with Special Reference to the "Cathaysia" Problem*

Editor's Note This is the earliest main paper on the diwa theory published in the initial period of development of the theory. In the paper, the author preliminarily analysed from a new viewpoint the geological development histories and metallogenic features of the Yinshan Mountains and Southeast China, based on his own many years' field investigation and other geologists' information. He suggested that the two regions were neither platform, as written in many documents, nor geosynclinal, as said recently, but new-type tectonic regions. They were formed when some parts of the Chinese platform underwent activation in Mesozoic time. The author named this kind of tectonic region an "activated region"① and named Southeast China the "Cathaysian activated region".

The author proposed the term "activated region" (renamed "diwa region", in 1959) and looked on it as a new-type tectonic element. The idea smashed the trammels of the geosyncline-platform theory which had governed geological sciences for more than 100 years and held that there were only two tectonic elements (geosyncline and platform) in the earth's crust. It became the embryonic form of the diwa theory. From the beginning on, the author paid much attention to the relationship between tectonics and metallogeny, and considered that activated regions were of great significance for metallogeny. The nascency of the paper was listed as one of the great events in the history of natural sciences (*The Chronological Table of the Great Events in the History of Natural Sciences*, p. 202, published by the Shanghai People's Press; *Concise Chronological Table of the World's Science and Technology History* (p. 145), edited by Juntaro Ito, *et al.*, published by Kobendo Sha, Japan, 1983). In 1976, E. A. Alexandrov, in reviewing the book *Metallogeny of Regions of Autonomous Activation* by A. D. Shcheglov, wrote that "credit is given to Chen Guoda of China and Beloussov of the Soviet Union who stressed the importance of autonomous activation in 1956 and 1964, respectively" (Economic Geology, 1976, Vol. 17)

Abstract

(1) The Yinshan region is an example of "activated region" in the Chinese platform.

One of the most typical localities that show clearly the phenomenon of "platform activation" is the Yinshan region, an east-west trending mountain range on the border between the North China plain and the Mongolian plateau.

* Published in Acta Geologica Sinica, 1956, 36(3): 239 – 271, Beijing. English vesion in *Selected Works of Chen Gou-da's Theory of Activated or Geodepression (Diwa) Tectonics*, 1 – 26, Changsha: Central South Univ. Press, 1990

① Originally it was written as "activizing region".

The region has long been recognized as a platform because of the facts that Mesozoic crustal movements and magmatic activity are important within this area. Some geologists, including Yu. M. Sheinmann, hold that it is a geosynclinal region.

It is Yu. M. Sheinmann who first noticed the phenomenon of activation in the Chinese platform. V. M. Sinitzin in his paper "Structure and Development of the Chinese Platform" indicates that some of the mountain ranges, including the Yinshan region, interpreted as fold belts developing from geosynclines, are in fact internal structures of the Chinese platform.

In this paper the author assigns the Yinshan region as one of the "activated regions" in the Chinese platform, and gives more detailed descriptions and discussion mainly on the basis of the history of its stratigraphic development.

Really it is a fact that the Yinshan region has an old folded basement composed of metamorphic rocks such as gneiss and old granitic intrusions apparently pre-Sinian in age. After the formation of this folded basement in the Luliang orogeny, the Yinshan old land was in a long period of denudation in the Paleozoic, although some Cambrian marine limestone, only 144 m in thickness, was deposited in the western part. At the end of the Paleozoic, local activation with formation of continental basin-deposits of Cambrian age, up to 1 380 m in thickness, took place in the Daqingshan area. In the middle Mesozoic, the Yinshan region came to a period of strong activity. Structural depressions due to acrogenesis occurred everywhere within the whole region and magmatic activity in large magnitude accompanied this crustal movement, so that a great sequence of fresh-water basin-deposits with intercalations of volcanics up to 8 000 m in total thickness were formed. During the formation of these strata, especially at the end of the Mesozoic, interruptions of deposition happened frequently, folds and thrusts were abundantly formed, and intrusive bodies of "young granite" were produced here and there. In the Tertiary, the Yinshan region was violently faulted, and volcanic activity still happened producing basaltic lava flow spreading over a wide area. The activity of the Yinshan old land has not ceased even today as shown by the fact that its whole area is in the process of uplift and by the presence of a seismic zone known in the historical time.

(2) What tectonic element is the coastal region of Southeast China?

Along the southeastern coast of China there is a district where tectonic characteristics have not been recognized clearly. It is A. W. Grabau who first referred it to an old land named "Cathaysia". J. S. Lee held the same opinion. In his tectonic map of China, V. Sinitzin also assigned the region to a platform and marked it as a part of his "South China platform massif". However, there is still another opinion opposed to this. A. S Homintovsky, for instance, referred this region to a geosynclinal region and proposed the name "Fujian-Zhejiang Pacific fold belt" for it. H. T. Yang and T. Y. Yu agreed with him.

In 1954, the author in his compiling work about the geology of Fujian and Guangdong Provinces found that the tectonic characteristics of the southeastern coastal region of China were not only inconsistent with those of a platform region, but also in contrast with those of a geosynclinal region. In fact, it can not be referred suitably to any tectonic element except to a new type as shown by the history of its geological development. Apparently it is an "activated" region.

During the pre-Devonian crustal movement (the Caledonian orogeny), a folded basement composed of gneisses, schists and phyllites was completely formed. Obviously this was a part of the broad old land of South China.

In the earlier stage of the Devonian, the whole region lay above sea level and under denudation. Hence, no sediments of any kind was deposited.

At the begining of the middle or late Devonian, depressions occurred in the western part of the region, where Devonian-Lower Carboniferous continental sediments consisting of quartzite, conglomerate and shale were laid down, but the other parts were still under denudation. These facts show that the region was still a land at that time.

The Uralian and the Lower Permian limestones, known respectively as the Chuansha and the Qixia limestones, separated from each other by a disconformity, occur widely in the region. This indicates that marine transgressions really happened in the southeastern coastal region of China. However, the thickness of these limestones (only 30 and 150 m respectively) and their uniformity in horizontal direction show that the sea at those times was shallow and the

amplitude of subsidence within this region was small.

The unnoticed lateral lithological change of these limestones proves the same fact. Undoubtedly these limestones are nothing but platform-type marine sediments. From the Late Permian to the Triassic, the region was under a condition of alternation of transgression and regression. Owing to the fact that the amplitude of crustal oscillation in the region at that time was small, sediments deposited during transgressions were thin and interrupted again and again by disconformities (or even unconformities). Sometimes continental sediments were intercalated.

Since the Late Triassic, the region has never been covered by sea water again. A new regime began to govern in the Late Jurassic. The old land became reactivated, so that a series of depressions were formed as a result of acrogenesis. In association with the subsidence of these depressions, continental beds with a total thickness of up to 3 000 m were deposited. In the beds hiatus frequently occurred. Folds were abundant, although they or at least some of them were intermediate in type. At the same time, magmatic activity was significant. It occurred mostly in the form of volcanic eruption as recorded by a sequence of tuff and rhyolite intercalated in the continental beds mentioned above. Then, at the end of the Mesozoic, numerous granitic bodies were intruded. Coming to the Cenozoic, the region still suffered from rather strong crustal movements accompanied by basaltic eruptions. The activity of the old land has not yet ceased today as marked by the presence of a famous earthquake zone between Guangdong and Fujian Provinces, and by the abundance of hot springs within the region. All these show the typical features of an "activated" platform. Finally, the complexity of deposit types found in Fujian and Guangdong Provinces also proves the tectonic nature of the region.

Summarizing the whole matter, we may say that the southeastern coastal region of China was originally an old land. Although it was again and again submerged by sea water, the resultant marine sediments are entirely different from those of a geosynclinal region. In the middle Mesozoic, this region began to be active violently again, producing a series of depressions in which thick continental beds were deposited. At the same time, open folds, volcanic eruption and magmatic intrusion occurred. Hence, it is reasonable to refer the southeastern coastal region of China to an "activated" region.

The northwestern boundary of the "activated region" is generally on the line starting from central Zhejiang through central Jiangxi to southwestern Guangdong Provinces, because the history and characteristics of geological development of southeastern Jiangxi and southwestern Guangdong Provinces are quite similar to those of Fujian and eastern Guangdong Provinces.

As to the nomination of this tectonic element, the author proposes to call it the "Cathaysian activated region". This name is derived from the "Cathaysia" of A. W. Grabau but it includes, according to necessity, the meaning of "activated" characters of this region. The so-called "Fujian-Zhejiang Pacific fold belt" of A. S. Homintovsky is obviously unacceptable because it entirely does not coincide with the fact.

Compared with the "activated" regions found in other parts of the world, the Cathaysian coastal "activated" region has its own characteristics, especially shown by the presence of numerous, widespread and small depression belts, and acid magmatic activity on a large scale. All these indicate that this is a special type different from all the known "activated" regions.

1 Introduction

As described by E. V. Pavlovsky (1954), the phenomenon of platform activation is the process by which platforms, after having experienced a relatively "stable" period, undergo activation. In platforms there appears strong acrogenesis (sometimes accompanied by faulting), which results in the formation of large uplifts and depressions and occurrence of new sedimentary conditions. In

depressions uplift – derived clastic sediments accumulate. As depressions subside deeper and deeper, more and more sediments are deposited. As a result, strata with a thickness of more than 1 000 m are formed. Because the subsidence is accompanied by volcanic activity, thick pyroclastic effusives are intercalated in the strata. Subsequently, the strata are folded and uplifted, accompanied by intense magmatic emplacement, and folds form in the platforms. The depression, the process of evolution of which is similar to that of a geosynclinal region, is named by the author "depression of activated platform"①. The region which has undergone platform activation is called "activated region" or "activated platform".

At first, the paper discusses the process of evolution of the Yinshan Mountains, which are a very good example of platform activation in the Chinese platform. Then, the paper deals with the tectonic nature of the southeastern coastal region of China, about which there are many different opinions.

2 The Yinshan Region—One of the Best Examples of Activated Region in the Chinese Platform

2.1 Brief History of Research

The Yinshan region is a long and narrow strip-shaped region which trends east and lies between North China and the Mongolian Plateau. Most geologists considered the region a platform region. For example, Huang Jiqing (1945) and Xie Jiarong (1953) considered it the "Inner Mongolian earth's axis"; Yu Deyuan (1954), the "Yinshan old land". A. C. Homintovsky (1953) also classed it as a part of the "Chinese Precambrian Block". As early as 1928 and 1932, Wang Zuwian and then Sun Jianchu pointed out that Daqingshan mountain and its eastward extension are composed of Precambrian crystalline schists and gneisses, over which lie unconformably Sinian and Cambrian unmetamorphic marine and Mesozoic (locally Upper Paleozoic) continental sediments. In fact, west of Daqingshan mountain, there still exist outcrops of the metamorphic rocks, overlain by Paleozoic platform-type sediments. Therefore, it is reasonable to consider the region a platform. But during the late Mesozoic, the region was subjected to intense folding, accompanied by intense emplacement of granite. Based on this evidence, some geologists looked on the region as a geosynclinal region, such as G. Sheinmann (1929).

2.2 Stratigraphy

Before the tectonic nature of the region can be discussed, we should analyse its stratigraphy. According to the author's investigation and information from Wang Zhuqian (1928), G. B. Barbour (1929), Sun Jianchu (1934), Tian Benyu and Gao Huang (1952), Geological Term of Baiyunebo (1951), Li Xingxie (1954) and Cheng Shenfu (1955), the author summarizes the stratigraphy of the region as Table 1.

① After 1959, it was renamed as "diwa (geodepression)".

Table 1 Stratigraphy of the Inshan Region

age	formation	thickness(m)	description	contact
Quaternary			alluvium and aeolian sands	
			tuff bed	
		0 – 10	loess	
		20 – 40	gravel bed	
		20 – 40	sand bed	unconformity
Tertiary	Hannuoba	30 – 60 190 – 200	red clays with sandstone and gravels basalt and coal measures; plateau basalt rich in olivine, interbedded with yellow shale and lignite in the lower part, containing *Pinus*	unconformity
Cretaceous	Nantianmen	600 – 2 500	conglomerate intercalated with rhyolite, fine shale, marl and coal-bearing shale at base	unconformity
	Zhangjiarou	700 – 2 000	acid lava and porphyry with conglomerate and tuff	unconformity
Jurassic	Daqingshan	650	conglomerate, sandstone and shale, containing *Estheria*	unconformity
	Xiaobeiling	250	shale, sandstone and conglomerate	unconformity
	Shiquai coal measures	1 800 – 2 300	sandstone interbedded with shale, limestone, coal seams and oil shale containing *Coniopteris*	unconformity
Triassic—Permian	Salaqi	1 200	red conglomerate, sandstone and shale	unconformity
	Shuanmachun	100 – 180	shale and sandstone with several coal seams, locally with conglomerate containing *Sphenophlliu tonium*	unconformity
Cambrian	Changshan	26	marl with wormkalk, containing *Kaolishshaniella*	hiatus
	Gushan	6.9	wormkalk with oolitic limestone, containing *Blackwelderia sinensis*	
	Zhangxia			
	Xuzhuang	70.8	limestone containing *Obolus*	
		40	purple shale	
Sinian	Nakou	270 – 1 000	siliceous limestone, quartzite and shale	unconformity
pre-Sanggan	Guyang		micaschist, phyllite, quartzite and marble	unconformity
	Sanggan			

There are two kinds of granite (old and new) in the region. The old granite intruded the Sanggan gneiss (Fig. 1). The Sinian limestone rests unconformably on the granite, which suggests that the granite is emplaced before the Sinian. The new granite intruded pre-Tertiary strata. Apart from a part of the granite (the Mongolian granite) which was emplaced in the Hercynian, most granite affected the Jurassic rocks. The Jurassic rocks were partly metamorphosed into phyllite and quartzite in zones of contact with the granite. The Teetiary basalt usually lies on the granite, which indicates that the granite is formed between the Jurassic and Tertiary.

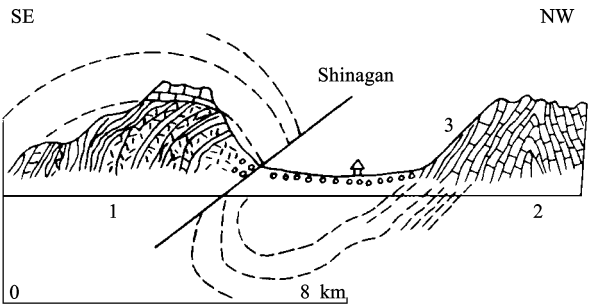


Fig. 1 Geological cross section around Shinagan, northwest of Seertengshan, Anbei County, Inner Mongolia

1) The Sinian rests unconformably on the pre-Sinian gneiss and granite; 2) Sinian limestone; 3) Permian coal measures (after Sun, 1938)

2.3 Geological Features of the Region

From the above it can be concluded that the region has a complex folded basement which consists of pre-Sinian metamorphic rocks (gneiss and schist) and the old granite (Fig. 1). The presence of a Precambrian folded basement is one of the major features of an ancient platform, so the region is an old land. After its formation in the Luliang orogeny, the southern part of the region experienced subsidence in the Sinian, and a E-trending syneclise (the "Yanliao subsidence") was formed. In the syneclise, limestone, sandstone and shale (quartzite and slate) with a thickness of between 900 and 9 260 m were deposited. In the early and middle Paleozoic, most of the region were in erosion, but in the western part (Seertengshan mountain), 144 m of limestone and shale were deposited in middle and late Cambrian time. In the Yanliao syneclise, sediments with a thickness of between 700 and 1 480 m were laid down in Cambrian and Ordovician time. In Silurian and Devonian time, the region, together with other parts of the North China platform, rose above sea level and no sediments were deposited. In middle Carboniferous and Permian time, platform-type mixed continental and marine and continental sediments were laid down in the region (Li, 1952). From Paleozoic sediments it is evident that after the formation of the folded basement, the region experienced erosion for a long time, and even marine sediments in most of the region exhibit features of a platform cover. All these facts show that at that time the Yinshan region was a platform region.

In the late Paleozoic, after having experienced a long "stable" period since the Cambrian, the

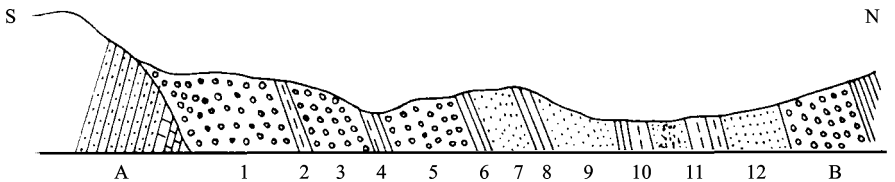


Fig. 2 Unconformity between the Carboniferous-Permian and the Sinian in Saxian County, Inner Mongolia

1—Sinian quartzite and limestone; 1 – 12—Carboniferous-Permian coal measures; B—conglomerate and red shale (after Wang, 1928)

region was activated. As mentioned above, the Carboniferous and Permian continental sediments reach a thickness of 1 380 m in the Daqingshan region. They rest on the older strata with an unconformity (Fig. 2) marking the Hercynian orogeny. That is to say, in the Hercynian orogeny, the crust of the platform region began to be mobile and underwent acrogenesis. At the same time, some depressions (activated platform depresions) were formed by arcogenesis in the western part of the region. In the depressions the Carboniferous-Permian continental sediments accumulated. In middle Mesozoic time the Yinshan region as a whole underwent activation, and a lot of intermontane depressions formed (Fig. 3). In these depressions the Jurassic sediments (coal-bearing and other continental sediments) with a thickness of between 2 700 and 3 200 m were deposited. The unconformity between the Jurassic and the older strata (Wang, 1928) marks an increased tectonic

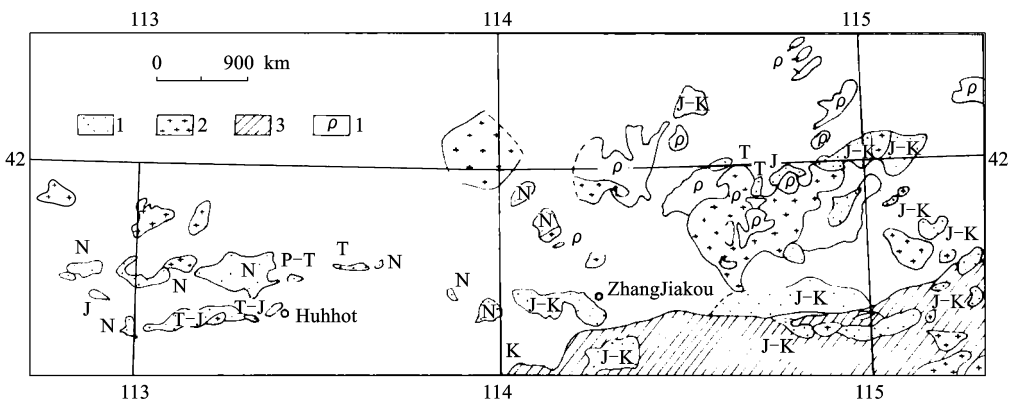


Fig. 3 Simplified structural map of the Yinshan region

1—Mesozoic and Tertiary depression; 2—Mesozoic granite; 3—Sinian depressions; 4—rhyolite and other acid extrusives (Mesozoic) N—Neogene, J—Jurassic, K—Cretaceous, T—Triassic

activity at that time. As arcogenesis increased in intensity, the depressions got deeper and deeper. As a result, the Jurassic and Cretaceous sediments reach a thickness of 4 500 m and the Cenozoic sediments, more than 300 m. That is, more than 8 000 m of continental sediments had been

deposited since Mesozoic time in the region (late Paleozoic time in its western part). The existence of several sharp unconformities between the Carboniferous and Cenozoic sediments shows that the region experienced intense mobility in the period. The subsidence of the intermontane depressions was accompanied by volcanic activity, which resulted in Jurassic and Cretaceous time in a lot of rhyolite, tuff and porphyry interbedded with conglomerate, sandstone and shale. The Zhangjiakou and Nantianmen Formations with a total thickness of more than 4 500 m were just deposited in such an environment. As a result of intense folding in late Mesozoic time, the strata in the depressions were severely folded and thrust. The Yinshan Mountains were characterized by thrusts and overfolds within the Jurassic sediments, as exemplified by large E-trending thrusts in Daqingshan and Langshan mountains (Figs. 4 and 5). Folding was accompanied by intense magmatic emplacement, resulting in granitic intrusions such as in Daqingshan, Wulashan, Seertengshan and Langshan

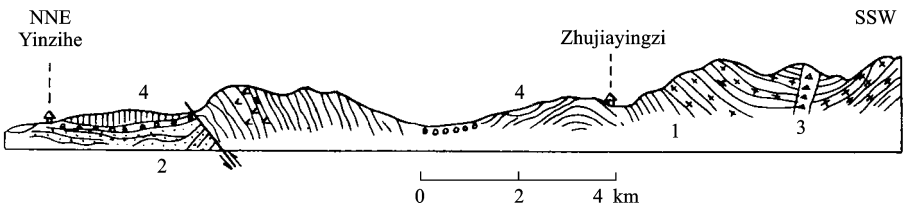


Fig. 4 Geological cross section in Xinghe County from Yinzihe to Zhujiayingzi, Inner Mongolia

1—gneiss; 2—Jurassic sandstone and shale; 3—diabase; 4—loess (after Sun Jianchu)

mountains (see Fig. 3; a part of the granite is probably the "Mongolian granite"). In Tertiary time, basaltic flows were erupted, and crustal movements were characterized by numerous E-trending strike-slip faults (Fig. 5), such as those in Daqingshan and Wulashan mountains (Sun, 1932). Furthermore, a series of basins formed in the southern part of the region, such as the Huailai basin (Gao, 1953). In the Quaternary the region is still rising, and a lot of gorges formed in the transition zone between the Mongolian Plateau and North China Plain. The gorges show features of young topography. There exist gullies of Ginghui and Banqiao ages in the gorges of Fenhe age (Fig. 6) (Sun, 1934), which records the uplift of the crust. In addition, the Quaternary glacial sediments, if any, are also an evidence for the uplift of the crust. The Yinshan region, especially the Nankou area (Weng, 1923), is a famous seismic area, which suggests that the region is still active.

2.4 Types of Mineral Deposit

As pointed out by V. H. Pavlinov (1954), mineral deposits in activated regions in type those in platform and geosynclinal regions. Mineral deposits formed in the Yinshan region support this statement. In th Yinshan activated region gold deposits are found in Archean rocks, e. g. gold deposits in southwestern Liaoning Province. As a result of emplacement of the pre-Sinian granite, asbestos and graphite deposits were formed in the Sanggan Gneiss in Inner Mongolia (Sun, 1934). The Sinian transgression affected the syneclise in the southern part of the region, forming sedimentary iron deposits of shallow-sea facies, such as the Yuantongshan iron deposit, Xuanhua

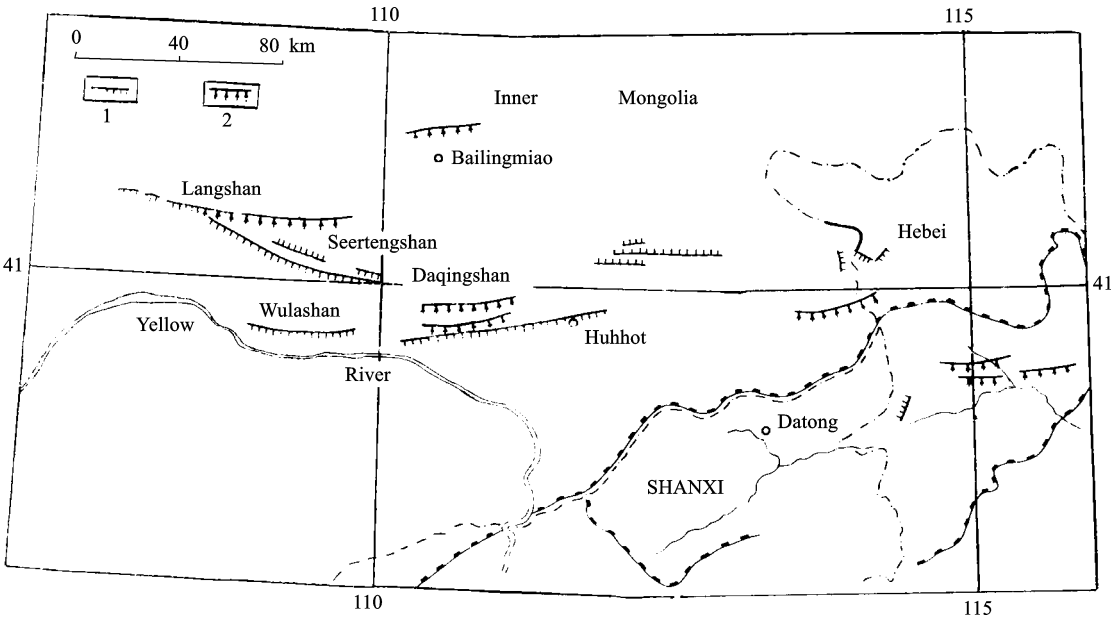


Fig. 5 Map showing the distribution of thrusts (1) and faults (2) in the middle western part of the Yinshan region (after Sun Jianchu)

County. In Mesozoic time, as the result of the activation and magmatic activity, many geosynclinal-type-like metallic and non-metallic deposits were also formed, such as copper, silver, lead, zinc and other nonferrous ore deposits found in the eastern part of the Yinshan activated region. According to the 241 Geological Team, large iron deposits in the Baotou area were formed in Mesozoic time, although many geologists considered them as the products of emplacement of the Mongolian granite. In the Chifeng and other areas, there existed pyrophyllite deposits which were genetically associated with the Mesozoic extrusives.

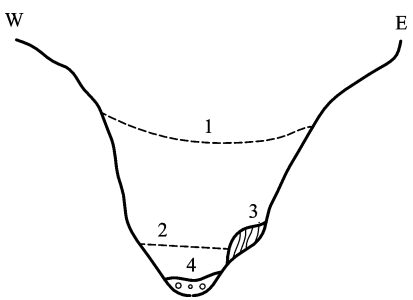


Fig. 6 Form of gorge

1—form of gorge of Fenhe age; 2—form of gorge of Qingshui age; 3—loess bed; 4—form of gorge of Banqiao age (after Sun Jianchu)

In activated regions, apart from platform-type and geosynclinal-type-like endogenic deposits, there usually appear favourable conditions for formation of some new-type sedimentary deposits. For example, platform activation may result in many intermontane depressions, in which thick sediments provide favourable conditions for formation of new-type, important coal fields (locally with oil shales). In the Yinshan region, the Carboniferous-Permian intermontane sediments contain coal seams, such as those in the Shuanmachun and Salaqi coal fields, Inner Mongolia (Wang, 1928; Sun, 1934). At that time, the

region just began to be activated, and intermontane depressions were not very deep. Coal beds formed in the depressions are widespread, although they are small in number and tonnage. In the Mesozoic, new-type coal fields formed in the region were typical such as the Jurassic coal fields in Inner Mongolia. They are called "activated platform depression-type coal fields"①. They contain huge reserves and many coal beds, locally with oil shale (Wang, 1928; Sun 1934). They are exemplified by the Shiquai coal field. In Cenozoic time, large Tertiary lignite fields and Quaternary peat fields were formed in the depressions, such as the Maliantan lignite field and the Taigemu peat field (Wang, 1928).

2.5 Conclusion

The Yinshan region was a platform region before Sinian time. In late Paleozoic time, part of the region underwent activation. In the Mesozoic, the region as a whole underwent intense activation. It is a good example of activated region in the Chinese platform.

3 What Tectonic Element Is the Southeastern Coastal Region of China

3.1 Brief History of Research

Along the southeastern coast of China there is a district where tectonic characteristics have not been recognized clearly. This district includes Fujian, most of Guangdong, and southern Zhejiang Provinces. It was A. W. Grabau (1924) who first referred it to an old land named "Cathaysia". J. S. Lee (1939) held the same opinion. In his tectonic map of China, V. M. Sinitzin (1948) assigned this region to a platform and marked it as a part of his "South China platform massif". However, there is still another opinion opposed to this. A. S. Homintovsky (1953), for instance, referred this district to a geosynclinal region and proposed the name "Fujina-Zhejinag Pacific fold belt" for it. H. T. Yang (1954) and T. Y. Yu (1954) agreed with him.

In 1954, the author in his compiling work (based mainly on his own field observations since 1930) about the geology of Fujian and Guangdong Provinces found that the tectonic characteristics of the southeastern coastal region of China are not only inconsistent with those of a platform region, but also in contrast to those of a geosynclinal region. In fact, it cannot be referred suitably to any tectonic unit except to a new type as shown by the history of its geological development. Apparently it is an "activated" region proposed by the author in 1956.

In this paper, the author will discuss this problem mainly on the geological history of the stratigraphic development of the region.

3.2 Brief Description of the Stratigraphy

The stratigraphy of the region with which this paper deals may be briefly stated as Tables 2, 3 and 4 and Fig. 7.

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① After 1959, they were renamed as "diwa-type coal fields".

Table 2 Stratigraphy of northwestern Fujian Province

(Tan, 1930; Chen, 1941; Cheng, 1950; Kao, 1947)

age	formation	code	thickness(m)	description	contact
Q		A – 1		alluvium	
		A – 2	30	red clay	unconformity
Tr	Mingxi	A – 3	50	soft conglomerate, sandstone, sandy shale and clay	unconformity
		A – 4		basalt	unconformity
	Chishi	A – 5	300	red conglomerate sandstone and shales	unconformity
K	Bantou	A – 6	500	light grey clayey thin-bedded shale, sandstone and conglomerate of lacustrine facies with *Onychiopsis*, *Pagiophyllum gracile Sze*	unconformity
K – J	volcanic	A – 7	1 500	purple shale, greyish green tuff sandstone, shale and conglomerate, intercalated with reddish rhyolite, tuff and agglomerate; thick green rhyolite at top	unconformity
J	Lishan	A – 8	500	sandstone, arkose, shale and black shale with intercalations of thin coal seams, containing *Podozamites*, *Cladophlebis*, etc.	unconformity
t	Shuikou	A – 9	200	calcareous shale with polecypods remains	unconformity
P	*Gigantopteris*	A – 10	40 – 500	sandstone, black shale, containing *Gigantopteris*	disconformity
	Wenbishan	A – 11	150	black shale interbedded with sandstone, sandy shale, carrying marine fauna	unconformity
	Qixia	A – 12	100	limestone with chert-nodules and chert-layers, especially in the upper part, frequently changing into shaly limestone; coral remains abundant	disconformity
C	Chuanshan	A – 13	10 – 30	thick-bedded limestone with scarce chert-nodules, furnishing *fusulinids* of typicl Uralian such as *Pseudoschwagerian princeps*, etc	unconformity
C – D	Nanjing	A – 14	900	white quartzite, quartzitic conglomerate with intercalations of thin-bedded, red sandy shale or phyllite	unconformity
Pre-D	Luoxifeng	A – 15	1 000	fresh red and light grey phyllite	unconformity
	Schist	A – 16	1 000	hornblende-schist, micaschist, quartz-schist, chlorite-schist and gneiss	

Table 3 Stratigraphy of southeastern Fujian Province

(Hou, 1935; Chow, 1950; Chen, 1933)

age	formation	code	thickness(m)	description	contact
Q		B – 1 B – 2		alluvium gravel and cave deposit	unconformity
Tr	Chishi	B – 3 B – 4 B – 5	700	red gravel interbedded with clay beds basalt red sandstone and shale with basal conglomerate	unconformity unconformity
K	Bantou	B – 6	200 – 300	conglomerate sandstone and shale with traces of plant fossils	unconformity unconformity
K – J		B – 7	500 +	lower part: sandstone and shale intercalated with rhyolite and conglomerate; upper part: rhyolite 200 m thick	unconformity
J	Lishan	B – 8		coal measures, consisting of sandstone and shale with intercalations of conglomerate and quartzite, containing *Podozamites*, *Cladophlebis*	unconformity
T	Shuikou	B – 9	200 +	shallow sea deposits: shale, sandstone and limestone with *Pseudomotis*, *Meekoceras*	unconformity
P	Cuipingshan	B – 10	200 +	clayey shale and sandy shale with intercalations of thin-bedded sandstone, containing *Lobatannularia* and *Gastrioceras*, etc.	
	Gigantopteris	B – 11	200 – 300	coal measures, consisting of sandstone and shale with plant fossils *Gigantopteris*, *Lobatannularia*, etc.	disconformity
	Wenbishan	B – 12	120 – 300	shale with a cherty conglomerate at base, bearing brachiopods: *Parenteletes*, *Schizophoria*, etc.	disconformity
	Qixia	B – 13	100 – 150	impure and chert-containing limestone bearing corals, *fusulinids* and brachiopods, etc.	unconformity/ disconformity
C	Chuanshan	B – 14	20 – 25	thick-bedded limestone, containing *fusulinids* and corals	disconformity unconformity
C – D	Nanjing	B – 15	1 000	compact quartzose conglomerate intercalated with shale, sandstone, quartzite and a few phyllites	unconformity
pre-D		B – 16	3 000 +	phyllite with quartzite, and partly quartzitic schist and mica schist	
		B – 17	2 000	mica schist and hornblende schist intercalated with chlorite schist, quartzose hornblende schist and paragneiss	unconformity
		B – 18		gneiss frequently with granite bodies	unconformity

Table 4 Stratigraphy of eastern Guangdong Province

(Yok, 1932; Chang, 1949; Chow, 1949)

age	formation	code	thickness(m)	description	contact
Q		C-1		alluvium	
Tr	Danxia	C-2	500	red sandstone, conglomerate and shale	unconformity
K-J		C-3	1 000 +	light green and dark red rhyolite	unconformity
J	Xiaoping coal measures	C-4	400	sandstone, shale with coal seams, containing plant fossils such as *Potozamites*, *Cladophlebis*, etc.	unconformity
P	Xinpu coal measures	C-5	460	shale and sandy shale intercalated with conglomerate and coal seams, bearing *Gigantopteris*, etc.	
	Youkeng	C-6	150	limestone with chert nobules containing *Michelinia*	disconformity
C	Maping	C-7	50	thick-bedded limestone	unconformity
pre-D		C-8		gneiss and mica schist	

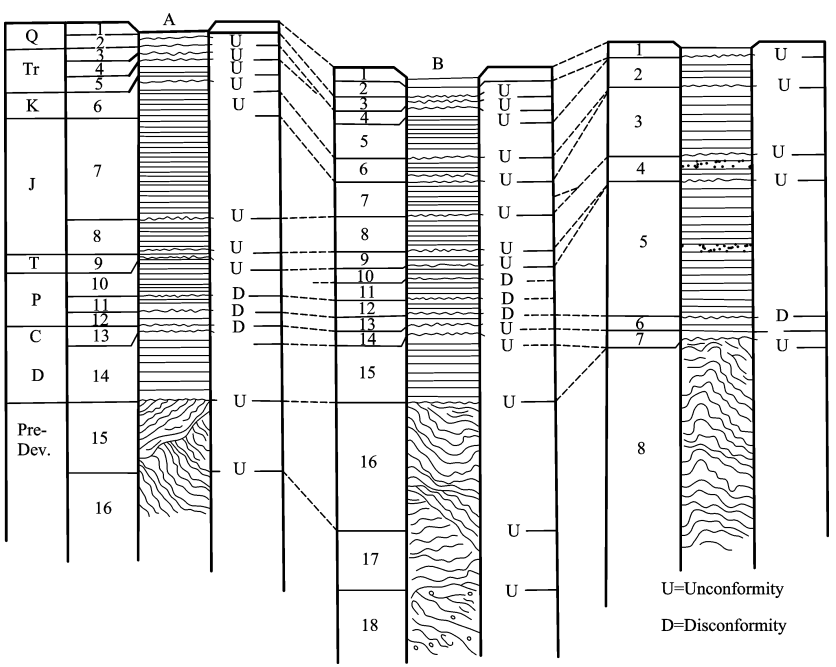


Fig. 7 Stratigraphical correlation between the regions of northwestern Fujian (A), southeastern Fujian (B) and eastern Guangdong (C)

3.3 Geological History and Paleogeography

From the facts stated in the preceding chapter, it is known that the stratigraphical development in the various parts of the region under discussion is quite similar to one another (Fig. 7). The general geological history of this region is described as follows.

3.3.1 The Consolidation of the Pre-Devonian Folded Basement

The metamorphic rocks, pre-Devonian in age, including the schist groups, the phyllite groups, and in some places also the gneiss groups, are widespread. Everywhere, they are folded seriously and overlain unconformably by all the younger strata (Fig. 8 – Fig. 10). These metamorphic rocks are exposed predominantly in the northwestern and central parts of Fujina Province such as the area between Jianning and Gutian (Tokyo Geographical Society, 1917), in the vicinities of Taining (Sheng, 1930, Chern, 1941), Songxi and Zhenghe (Chen, 1942), etc. In the central-eastern part of Guangdong Province such as Haifeng (Chiang, 1938), Wuhua (Chang, 1949), Puning (Chow, 1949), and coastal districts of Fujian Province, including Xiamen and Jinmen Island (Hou, 1935; China Geol. Surv., 1950), the Archean gneiss groups also occurs. Besides, they have been found in comparatively small areas in the southeast of Zhuji, Zhejiang Province (China Geol. Surv., 1950). These facts show that a folded basement composed of pre-Devonian metamorphic rock is undoubtedly present in the above-mentioned region.

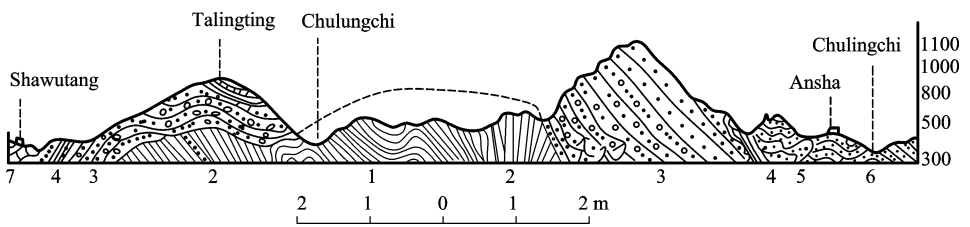


Fig. 8 Section from Shawutang to Ansha, Youn'an, Fujian Province

1 – 2—Luoxifeng phyllite series (pre-Devonian); 1—gray phyllite; 2—greenish phyllite. 3 – 6—Nanjing Series; 3—massive coarse quartz conglomerate; 4—purplish phyllite; 5—quartzite and quartz-conglomerate; 6—reddish quartz sandstone and white sandstone; 7—Qixia limestone (after Yang, 1944).

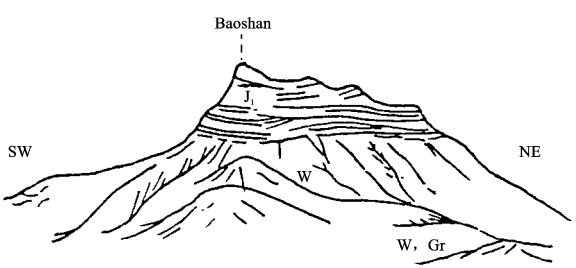


Fig. 9 Section showing the unconformable contact of the schist groups with the Lishan coal measures at Baoshan, Shunchang, Fujian Province

J_1—Lishan coal measures (sandstone); W—schist series (mica schist); Gr—muscovite granite (after Sheng, 1950).

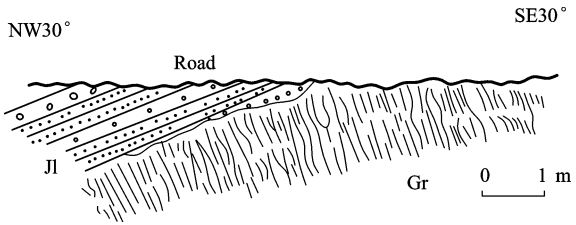


Fig. 10 Section showing the unconformity between the Lishan coal measures (J1) and the hornblende gneiss (Gr) (pre-Devonian), north bank of Dongxi, Jian'ou, Fujian Province (after M. K. Chern, 1941).

Geological investigations indicate that a regionally metamorphosed formation consisting largely of phyllites and quartzites occur in various parts of South China. It is represented by the Linchuan Group or the Shuangjiaoshan Group in Jiangxi, and the Banxi Series in Hunan Provinces. The lower part of this metamorphic formation is generally accepted as the equivalent of the Huto Group of North China. It is the main constituent that forms the folded basement of the South China platform. According to the lithological characteristics and the stratigraphical position, the pre-Devonian phyllite groups of the southeastern coastal region may be correlated with the Linchuan Series of Jiangxi Province. Obviously the folded basement of the said region is but a part of that of the broad South China platform.

3.3.2 The Early Devonian Erosion Period

There is no Lower Devonian deposit of any kind found in the main part of the region here under discussion. This indicates that nearly the whole area of this region with its Caledonian geosynclinal fold belt was exposed in the air and under denudation in this period.

3.3.3 The Formation of the Middle Devonian and Carboniferous Continental Deposits

The deposition on the folded basement of this region began to appear in middle Devonian time, but the first deposits are of platform and continental origin. They are represented by the Nanjing Formation of Fujian Province. It is composed chiefly of quartzites 900 – 1000 m in thickness, unconformably lying on the pre-Devonian metamorphic rocks (Fig. 2). In the central-southern part of Jiangxi Province occurs the Xiashan Formation (Chen, 1940). It has the similar lithological characters and stratigraphical position as the Nanjing Formation, containing at its uppermost part the Etroeungtian plant fossil *Sublepidodendron mirabile* (Nath.). It is believalbe that the Xiashan Formation as well as its equivalent, the Nanjing Formation, is from middle Devonian to lower Carboniferous in age.

No middle Carboniferous deposit has ever been proved to be present in this region except that some grayish white and yellowish brown shales of less than one hundred m in thickness occur between the Nanjing Formation and the Uralian beds as found in Shaxian, Fujian Province (Sheng, 1943). It was supposed to be the equivalent of the Zishan coal measures of Jiangxi Province, which

furnishes the typical Westphalian plant fossil *Neuropteris gigantea* Sernberg discovered by the author in 1937 (Chen, 1940). No matter this is certain or not, the region here under discussion was a land at that time.

3.3.4 Marine Transgression with Its Corresponding Deposits and Formation of Marine and Non-marine Alternating Beds from the Late Paleozoic to the Early Mesozoic

The Upper Carboniferous Chuanshan limestone occurs widely in this region. This was the first marine deposit since the foundation of the platform. However, in accordance with the smallness and uniformity of its thickness (being 30 – 50 m everywhere), it is nothing but a deposit lying on the broad and flat surface of a stable old land during the widespread transgression of the shallow sea. The unnoticed lateral variation of the lithological characters of this limestone that occurs in all the other parts of the South China platform possesses this same peculiarity.

At the end of the Uralian epoch, the southeastern coastal region of China once emerged from the sea, while in the early Permian period the sea transgressed again. The widespread Qixia limestone resulting from this marine transgression, with its thickness only 150 m, is also a shallow sea deposit on the flat surface of the platform.

After the Qixia transgression, the platform emerged from the water again. From the upper part of the lower Permian to the upper Permain this region came to a period of alternation of transgression and regression of the sea. The result was the formation of the Wenbishan Formation, the *Gigantopteris* coal series and the Cuipingshan Formation. The Wenbishan Formation is the equivalent of the Gufeng Formation of Nanjing Hills, while the *Gigantopteris* coal Formation and the Cuipingshan Formation are the representatives of the widespread Leping Formation of South China in this region. The Wenbishan Series, which consists of sandstone and sandy shale, 120 – 130 m in thickness, and furnishes the cephalopods *Gastrioceras* and the brachiopods *Parenteletes*, *Chonetes*, *Schizophoria*, etc., indicates that the region was a shallow sea at that time. The *Gigantopteris* coal series is a continental deposit. The disconformity between these two series also shows the emergence of the land. After the deposition of the *Gigantopteris* coal series, the phenomenon of alternation of the advance and retreat of the sea was still more obvious. This was recorded by the Cuipingshan Formation which is composed mainly of shale and sandy shale intercalated with some thin-bedded sandstone, 200 – 250 m in thickness. There are in this series abundant fossils, both marine and continental, including *Gastrioceras* (Cephalopods), *Products* (Brachiopods), *Lobatannularia* (plant remains) and semi-freshwater pelecypods such as *Carbonicola wangsoweni*, etc.

At the beginning of the Triassic, the land submerged once more. The Xikou Series which is composed of shale and sandstone intercalated with thin-bedded limestone, 250 m in thickness, is apparently a part of the widespread marine Triassic beds on the South China platform. It contains *Pseudomonotis*, *Meekoceras*, etc.

In short, from late Paleozoic to early Mesozoic, marine transgressions did happen in the southeastern coastal region of China, but it was merely a shallow, widespread sea covering the flat surface of the platform. This may be proved by the lithological characters, the smallness of

thickness, the stableness in rock facies and thickness in the lateral directions, and the plentifulness of the furnished fossils of the resulting deposits. Specially noticable is the smallness of the thickness of these marine beds. The total thickness of all of them, including even the Cuipingshan Formation which consists of marine strata with intercalated continental beds, is only 640 – 730 m. This shows that the amplitude of oscillation of the land was rather small. However, owing to the fact that the land surface of this region at that time was flat, even a slight subsidence would cause the sea to cover a vast area so that the marine beds with a small thickness but extensive spreading were formed. In the next stage a slight upheaval would make the sea entirely retreated. This also produced the intercalated continental beds as well as the disconformities or even slight unconformities between the successive formations.

3.3.5 Crustal Movements and Magmatic Activity Since Middle Mesozoic Time

In middle Mesozoic time, the southeastern coastal region of China came to an entirely new stage in its geological-historical development. As early as late Triassic, the sea retreated completely from this region. Instead of oscillatory movements in small amplitude, the whole area of the region became arched as the result of "process of acrogenesis" or arcuation[①](1953), so a series of linear, anticlinorium-like elevations extending generally in NE – SW direction and intercalated with synclinorium-like depression belts were produced (Fig. 11). Immediately powerful erosion began. Accompanying the progressing of the subsidence of the depression belts, a great sequence of continental deposits with a total thickness of 3 000 m were formed. These include the Rhaetic-Liassic coal measures, the Jurassic-Cretaceous volcanic series, the Cretaceous Bantou Formation which furnished the plant remain *Onychiopsis* and other fossils, the Tertiary red beds and the Mingxi Formation (Figs. 11 – 14). The enormous Jurassic-Cretaceous volcanic series up to 1 000 m in thickness (Figs. 11 and 12) indicates that volcanic activities were violent when the "arcogenesis" was in progress. Until the early Cenozoic, the volcanic eruptions still happened as shown by the Tertiary basalt.

Besides the volcanic eruptions there were immense granitic intrusions at the end of the Mesozoic (Figs. 7 and 8). The wide distribution of the granite and volcanic rocks is the most typical peculiarity of the southeastern coastal region of China. According to C. S. Kao (1944), in Fujian Province the outcrops of the granite and volcanic rocks occupy 40% and 20% – 30% respectively of the area of the province.

Strong crustal movements during the formation of the deposits in the depression belts were recorded by the pronounced unconformities among the different strata of Mesozoic and Cenozoic ages.

3.4 Remarks on the Tectonic Characteristics

To sum up all the facts mentioned above, we find that the tectonic characteristics of the southeastern coastal region of China are as follows.

① E. V. Pavlovsky named it as "процесс аркогенеза".

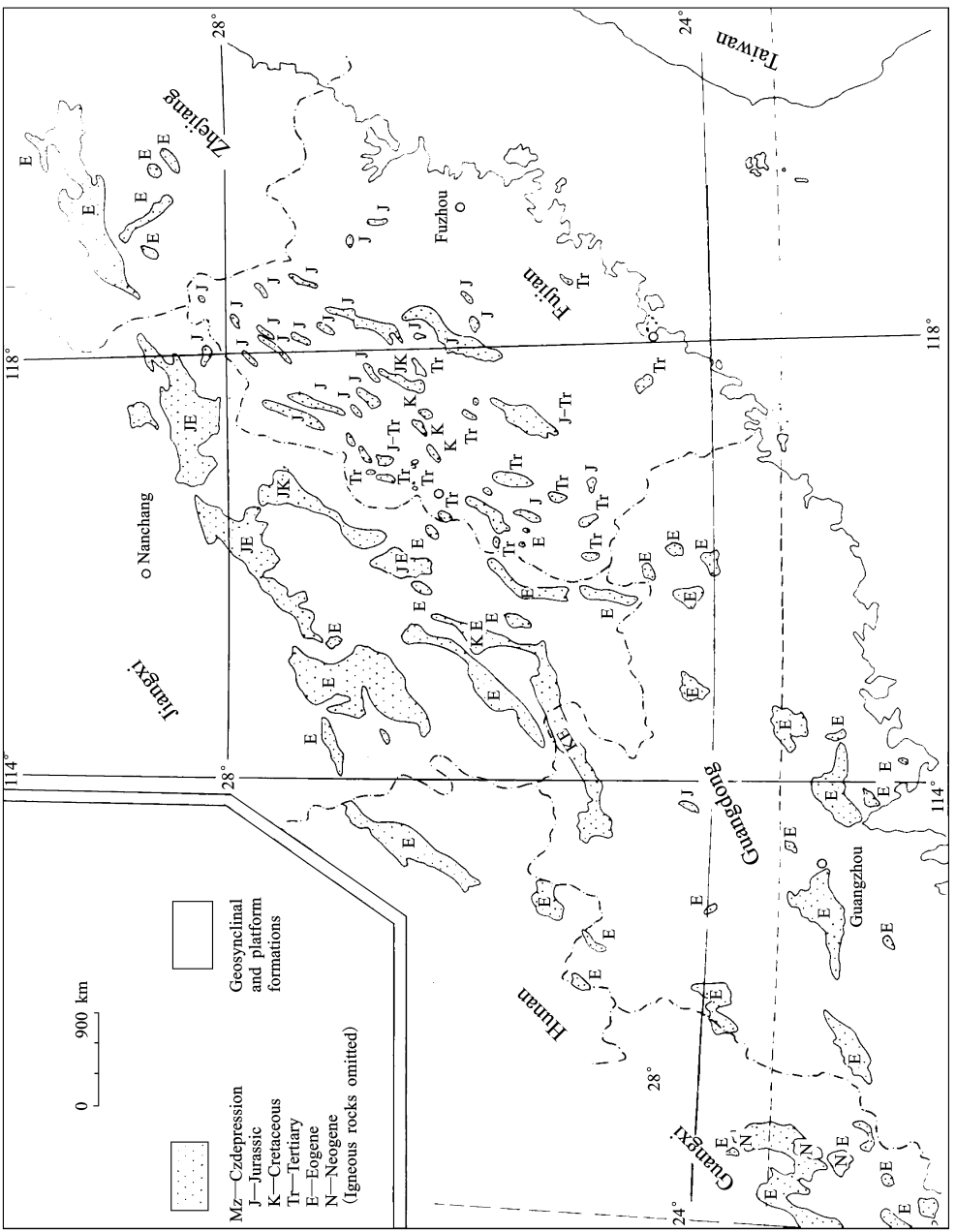


Fig. 11 Tectonic sketch map of the SE coastal region of China (after the Geological Map of China)

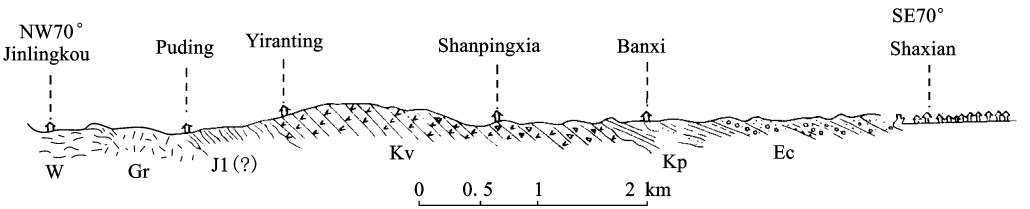


Fig. 12 Section across the western limb of the Shaxian basin, Fujian Province

W—pre-Devonian schist and gneiss; J1—Rhaetic-Liassic coal measures; Gr—granite; Kv—volcanic series (Jurassic-Cretaceous) (middle part); Kp—Bantou Formation (Cretaceous); Ec—Chishi Formation (Tertiary) (after Sheng, 1950)

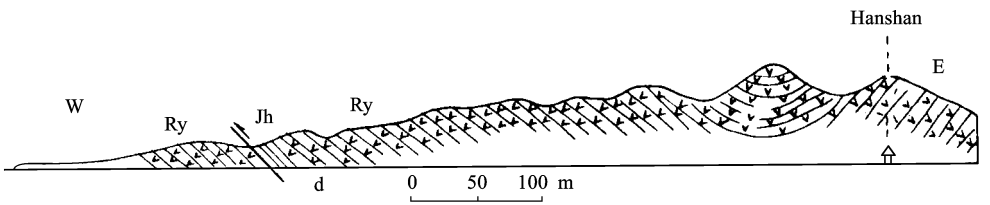


Fig. 13 Section of Hanshan, Chaozhou, Guangdong Province, showing the syncline and thrust

Ry—rhyolite; Jh—Xiaoping coal measures; d—disconformity (after Chang, 1944)

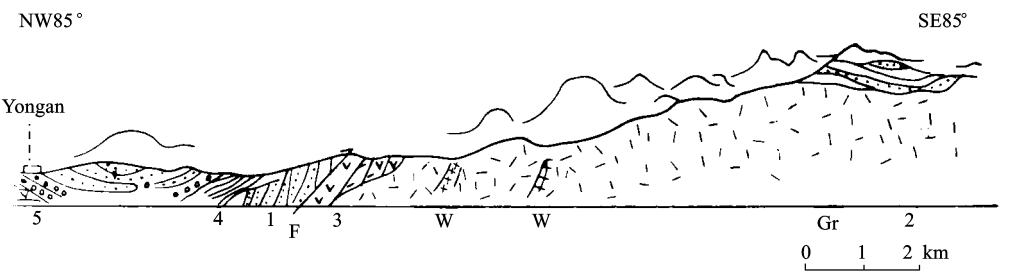


Fig. 14 E-W section through Yongan, Fujian Province

1—Nanjing Series; 2—Lishan coal measures; 3—volcanic Series; 4—Bantou Series; 5—red beds; Gr—granite; W—gabbro dike; F—thrust (after Yang, 1944)

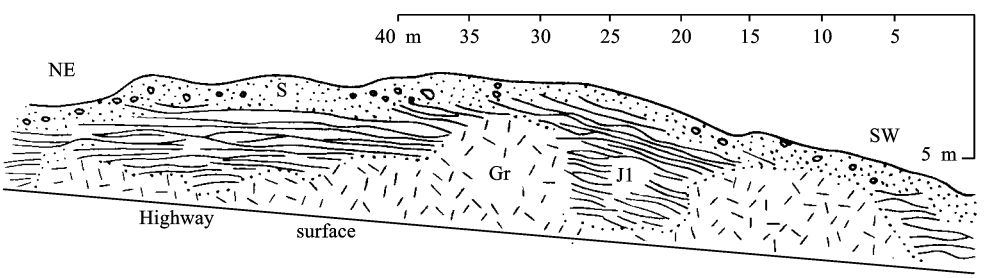


Fig. 15 A highway cut section at the western side of Xipeiling, showing the Lishan coal measures (J1) intruded by granite (Gr)

S—soil mantle (after M. K. Chern, 1941)

(1) It has a remarkable folded basement composed of geosynclinal sediments as all the platforms do.

(2) The early Devonian erosion period marks the age of the peneplanation of the Caledonian geosynclinal fold belt and the formation of the platform. The continental deposits formed in the Devonian and early Carboniferous show also a platform environment.

(3) Marine transgression did happen in the Late Paleozoic and early Mesozoic. However, the sediments resulting from these transgressions of the sea are merely deposits of platform type. They are entirely distinct from those formed in geosynclinal regions.

(4) In the middle Mesozoic, the geological development of this region entered a new stage—the stage of "activation" of platform as V. V. Beloussov calls it (1955). The original stableness of the land was substituted by great activity. The process of "arcogenesis" or arculation brought with it the new conditions of deposition. The continental sediments in great sequences, intercalated with numerous volcanic beds produced in the newly formed depression belts, are quite different from the sediments occurred in a platform, but similar to those appearing in the depressions of a mobile region. They generally furnish a special type of sedimentary mineral deposits (chiefly of coal and oil shale), which have been named by the author (1956) the "sedimentary mineral deposits of activated platform depression-type". In addition, the presence of the immense acid magmatic intrusions at the end of the Mesozoic, which are generally peculiar exclusively to mobile regions, is still noticeable.

(5) The folds formed during the Mesozoic crustal movements in this region have their own peculiarities. They are distinct both from those found in a platform and from those of geosynclinal type. Mostly they belong to the open type of holomorphic folds (Fig. 15) (Kao, 1941).

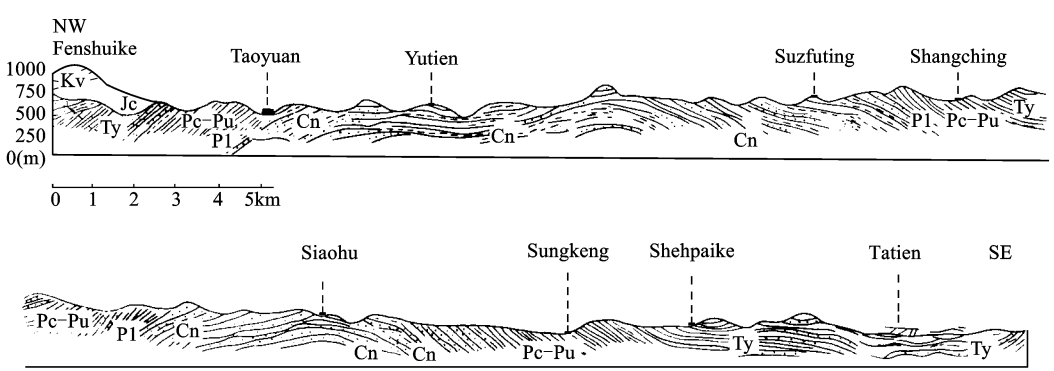


Fig. 16 Geological section along the highway between Dehua and Datian, Fujian Province

Cn—Nanjing Series (D-C); Pl—Xixia Series (P_2); Pc—*Gigantopteris* coal series (P_2); Pu—Yangping Series (P_2); Ty—Yangping series; Jc—Rhaetic-Liassic coal series; Kv—Cretaceous volcanic series (after Kao, 1941)

(6) Until the recent geological period, the process of activation of the said region has not yet ceased. This is proved by the presence of a famous earthquake zone occurring along the coast of

southeastern Fujian and eastern Guangdong Provinces (Yok, 1932; Chang, 1935; Chang, 1949). Finally, the repeated upheaval and subsidence of the coast of South China in Quaternary time (Hou, 1935; Ma, 1942 and 1947; Chen, 1951) also implies that the recent crustal movements of the region are not negligible.

3.5 Conclusion

The southeastern coastal region of China originally was an epi-Caledonian platform. Although it has been again submerged by the sea, the resultant marine deposits are entirely different from the deposits of a geosynclinal region. In the middle Mesozoic this region began to be active violently again, producing a series of depression belts. In these belts thick continental beds, up to thousands of meterm, had been deposited. At the same time, it was characterized by the formation of folds mainly of open type. Besides, voilent volcanic eruptions and immense magmatic intrusions were also typical of this region during the Mesozoic crustal movements. All these facts indicate that the tectonic nature of the region is distinct from both a geosynclinal region and a platform region. Thus, to refer the southeastern coastal region of China to an "activated" region is quite justified. Conspicuously it is one of the typical "activated" regions transformed from the vast Chinese platform.

As to the nomination of the tectonic unit, the author proposes to call it the "Cathaysian activated region." This name is derived from the "Cathaysia" of A. W. Grabau (1924), but it includes, according to necessity, the meaning of "activated" characters of this region. The so-called "Fujian-Zhejiang Pacific fold belt" of S. S. Homintovsky (1953) is obviously unacceptable because it does not entirely coincide with the fact.

The northwestern boundary of the Cathaysian "activated" region generally lies along the line starting from central Zhejiang through southern Jiangxi to southwestern Guangdong Provinces, because the history and characteristics of geological development of southeastern Jiangxi and central-southern Guangdong Provinces are quite similar to those of Fujian and eastern Guangdong Provinces. To the northwest of this boundary line lies another "activated region"—the "Zhejiang-Jiangxi-Hunan-Guangxi activated region" (Chen, 1956, 1957).

Compared with the "activated" regions found in other parts of the world, the "Cathaysian activated region" has its own characteristics, especially shown by the presence of numerous, widespread and small depression belts on a large scale. All these indicate that this is a special type different from all the known "activated" regions. It may be called the "SE activated region".

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On the Geotectonic Nature of the Southeastern Coastal Region of China*

Abstract According to the writer's opinion, the southeastern coastal region of China is neither a common platform as A. W. Grabau stated, nor a geosynclinal region as A. C. Хоментовский described. It is an "activizing or resurrected region" of the Chinese platform①.

In the said region there is a folded foundation composed of old metamorphic rocks pre-Sinian in age. During a long time of the Lower Palaeozoic Era, the whole area of this region was exposed in the air and under denudation. From Devonian to Lower Triassic, some marine beds were formed. However, they are nothing but the deposits of platform-type. Besides, continental deposits are intercalated. At the beginning of Rhaetic, a new condition happened. Here, a series of depressing belts were produced. In association with the subsidence of these belts, continental beds with total thickness up to 3 000 m deposited, accompanying with violent volcanic eruptions. At the end of Mesozoic, folds mainly belonging to the intermediate type, and granitic intrusions in a large scale took place. Until Middle Tertiary, there were still volcanic eruptions. The crustal movements have not ceased even today as shown by earthquakes, the shoreline development, etc. All these show that this region is an "activizing platform."

1 Introduction

On the southeastern coast of China there is a district whose geotectonic characteristics have never been recognized clearly. This district includes Fujian, the most part of Guangdung, and the southern part of Zhejiang. It was A. W. Grabau (1924) who firstly referred it to an old land named "Cathaysia". J. S. Lee (1939) held the same opinion. In his geotectonic map of China, B. M. Синицын (1948) assigned this region to a platform and marked it as a part of his "South-China platformal massive". However, there is still another opinion opposed to this. A. C. Хоментовский (1953), for instance, referred this district to a geosynclinal region and proposed the name "Minchê Pacific folding zone" for it. H. T. Yang (1954) and T. Y. Yu (1954) agreed with him respectively.

In 1954, the writer in his compiling work about the geology of Fujian and Guangdung, found that the geotectonic characteristics of the southeastern coastal region of China are not only inconsistent with those found in a common platform, but also in contrast to those of a geosynclinal region. In fact, it cannot be referred suitably to any geotectonic unit except the intermediate type as shown by the history of its geological development. Apparently it is an "activizing" or "resurrected" platform.

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① A term proposed by the writer in 1956.

In this paper, the writer will discuss this problem mainly on the geological history of the stratigraphic development of the said region.

2 Brief Description of the Stratigraphy

The stratigraphy of the region with which this paper deals may be briefly stated as follows:

2.1 Northwestern Fujian (Tan 1930; Chen 1941; Sheng 1950; Kao 1947)

Quarternary:

Alluvium

Red Clay 30 ± m

Unconformity

Tertiary:

Mingchi Formation—Soft conglomerates, sandstones, sandy shales and clay 50 ± m

Unconformity

Basalt

Unconformity

Chishih Formation—Red conglomerates, sandstones and shales 300 + m

Unconformity

Cretaceous:

Pantou Series—Light grey clayey thin-bedded shales, sandstones and conglomerates of lacustrine deposits with plant tossils *Onychiopsis*, *Pagiophyllum gracile* Sze, etc. 500 + m

Unconformity

Jurassic-Cretaceous:

Volcanic Series—Purple shales, greyish green tuff sandstones, shales and conglomerates, intercalated with reddish rhyolites, tuffs and agglomerates, In the uppermost part occur the thick beds of the light grey or greyish green rhyolites. 1 500 + m

Unconformity

Rhaetic-Liassic:

Lishan Coal Series—Sandstones, arkose-sandstones, shales and black shales with intercalations of thin coal seams and plant fossils *Thinnfeldia rhomboidalis* Ett., *Podozamites*, *lanceolatus* (L. et H.) *Cladophlebis*, etc. 500 + m

Pronounced unconformity

Triassic:

Chikou Series—Yellowish and greyish calcareous shales with polecypods remains 200 + m

Unconformity

Permian:

Gigantopteris Coal Series—Grey thin-bedded sandstones, black shale, containing *Gigantopteris*, etc 400 – 500m

Disconformity

Wenpishan Series—Greyish black shales interbedded with hard sandstones, sandy shales; carrying marine fauna (*Pecten* and *Gastriiceras*-like remains). 150 ± m

Disconformity or unconformity

Chishsia Limestone—Dark Grey limestone with chert-nodules and chert-layers, especially in the upper parts. The limestone frequently changes into shaly limestone. Coral remains abundant; *tylidophyllum volzi*, *Hayasakaia* sp. etc. 100 ± m

Disconformity

Carboniferous:

Chuanshan Limestone—Greyish white thick-bedded limestones with scarce or even in lack of chert-nodules, furnishing *fusulinids* of typical Uralian type such as *Pseudoschwagerina princeps*, etc. 10 – 30m

Unconformity

Devonian-Carboniferous:

Nanching Series—White quartzites, quartzitic conglomerates with intercalations of thin-bedded, red sandy shales or phyllites 900 + m

Unconformity

Pre-Sinian:

Phyllite Series—Consisting mostly of fresh red and light grey phyllites 1 000 m

Unconformity

Schist-Series—Composed mainly of hornblende-schists, mica-schists, quartzitic schists, chlorite-schists, etc., and partly of injection gneiss. 1 000 m

2.2 Southeastern Fujian (Hou 1935; Chow 1950; Chen 1933)

Quarternary:

Alluvium

Gravels and cave deposits

Unconformity

Tertiary:

Red Clay—Soft red gravel interbedded with clay beds.

Unconformity

Basalt

Unconformity

Chishih Formation—Red sandstones and shales with basal conglomerate. 700 m

Unconformity

Cretaceous:

Pantou Series—Conglomerates, sandstones and shales with traces of plant fossils. 200 – 300 m

Unconformity

Jurassic-Cretaceous:

Volcanic Series—Lower part: sandstones and shales with various colours, intercalated with rhyolite and agglomerate. Upper part: rhyolite with thickness up to 200 m. 500 + m

Unconformity

Rhaetic-Liassic:

Lishan Coal Series—Consisting chiefly of sandstones and shales with intercalations of conglomerates and quartzite; plant fossils abundant: *Podozamites*, *Cladophlebis*, etc.

Pronounced Unconformity

Triassic:

Chikou Series—shallow sea deposits: Shale, sandstone and grey or greyish white limestone with *Pseudomonotis*,

Meekoceras, etc. 200 + m

Unconformity

Permian:

Tsuipingshan Series—Composed largely of grey, greyish green and brownish yellow clayey shales and sandy shales with intercalations of thin-bedded sandstones, furnishing plant fossils (such at *Lobatannularia*, etc., in association with freshwater fauna) and marine fossils (such as *Gastrioceras*, etc.) 200 ± m

Disconformity

Gigantopteris Coal Series—Sandstones and black, grey and other coloured shales with plant fossils *Gigantopteris*, *Lobatannularia*, etc. 200 – 300 m

Disconformity

Wenpishan Series—Consisting mainly of shale, with a cherty conglomerate at the base, bearing brachiopods: *Parenteletes*, *Schizophoriz*, *Productus*, etc. 120 – 130 m

Disconformity or Unconformity

Chihsia Limestone—Grey to black, impure and chert-containing limestone. In the lower part, the chert is in the form of nodules, while in the upper part it forms beds and is still more abundant. Fossils: corals (*Stilidophyllum volzi*, *Hayasakaia* sp. etc.), fusulinids (*Verbeekina minor*, etc.), brachiopods, etc. 100 – 150 m

Disconformity

Carboniferous

Chuanshan Limestone—Thick-bedded greyish white (sometimes dark grey) limestones, containing fusulinids such as *Pseudoschwagerina princeps*; *Quasifusulina longissima*; etc., and corals 20—50 m

Unconformity

Devonian-Carboniferous:

Nanching Series—Consisting largely of compact quartzose conglomerates intercalated with shales, sandstones, quartzites and a few phyllites. 1 000 m

Unconformity

Pre-Sinian:

Phyllite Series—Composed mostly of greyish green, greyish yellow, greyish red, and greyish black phyllites with some quartzites, and partly of quartzitic schists and mica schists 3 000 + m

Unconformity

Schist Series—Composed chiefly of greyish yellow and greyish black mica-schists and hornblende-schists, intercalated with chlorite schists, quartzose hornblende-schists and paragneisses. 2 000 + m

Unconformity

Gneisses—Containing frequently with granite bodies.

2.3 Eastern Guangdong (Yok 1932; Chang 1949; Chow 1949)

Quarternary:

Alluvium

Unconformity

Tertiary:

Tanhsia Formation—Red sandstones, conglomerates and shales 500 m

Unconformity

Jurassic-Cretaceous

Volcanic Series—Chiefly composed of light green and dark red rhyolites 1 000 + m

Unconformity

Rhaetic-Liassic:

Hsiaoping Coal Series—consisting mainly of sandstones, shales with coal seams, containing plant fossils such as *Potozamites*, *Cladophlebis*, etc. 400 m

Unconformity

Permian:

Sinpu Coal Series—Yellow and grey shales and sandy shales intercalated with conglomerates and coal seams, furnishing *Gigantopteris*, etc. 450 m

Disconformity

Yiukeng Limestone—Greyish black limestones with chert nodules containing *Michelina* 150 m

Undetermined

Carboniferous:

Maping limestone—White, pure, thick-bedded limestones 50 m

Unconformity

Pre-Palaeozoic:

Gneisses and mica-schists.

3 Geological History and Palaeogeography

According to the facts stated in the preceeding chapter, it is suggested that the stratigraphical developments in the various parts of the region under discussion are quite similar to one another (Fig. 1). The general geological history of this region is concluded as follows.

3.1 The Consolidation of the Pre-Sinian Folded Foundation

The old metamorphic rocks pre-Sinian in age, including the schist series, the phyllite series, and in some places also the gneiss series are widely spread. Everywhere, they are folded intensely and overlain unconformably by all the younger strata (Figs. 2 – 4). These metamorphic rocks are exposed most predominantly in the northwestern and central parts of Fujian Province such as the area between Kienning and Kutien (Tokyo Geographical Society, 1917), in the vicinities of Taning (Sheng, 1950), Shunch'ang and Nanp'ing (Tan, 1930), Kienyang and Kienou (Wang, 1930; Chern, 1941), Sungchi and Chênho (Chern 1942), etc. In the central-eastern part of Guangdong such as Changch'eng, Polo (Chiang 1938), Wuhua (Chang, 1949), P'uning (chow, 1949), and the coastal districts of Fujian including Amoy and the Kingmen Island (Hou, 1935; *China Geol. Surv.*, 1950), the Archaean gneiss series also occur. Besides, they have been found in comparatively small areas in the southeast of Chuchi, Zhejiang Province (*China Geol. Surv.*, 1950). These facts show that a folded foundation composed of pre-Sinian metamorphic rocks is undoubtedly present in the said region.

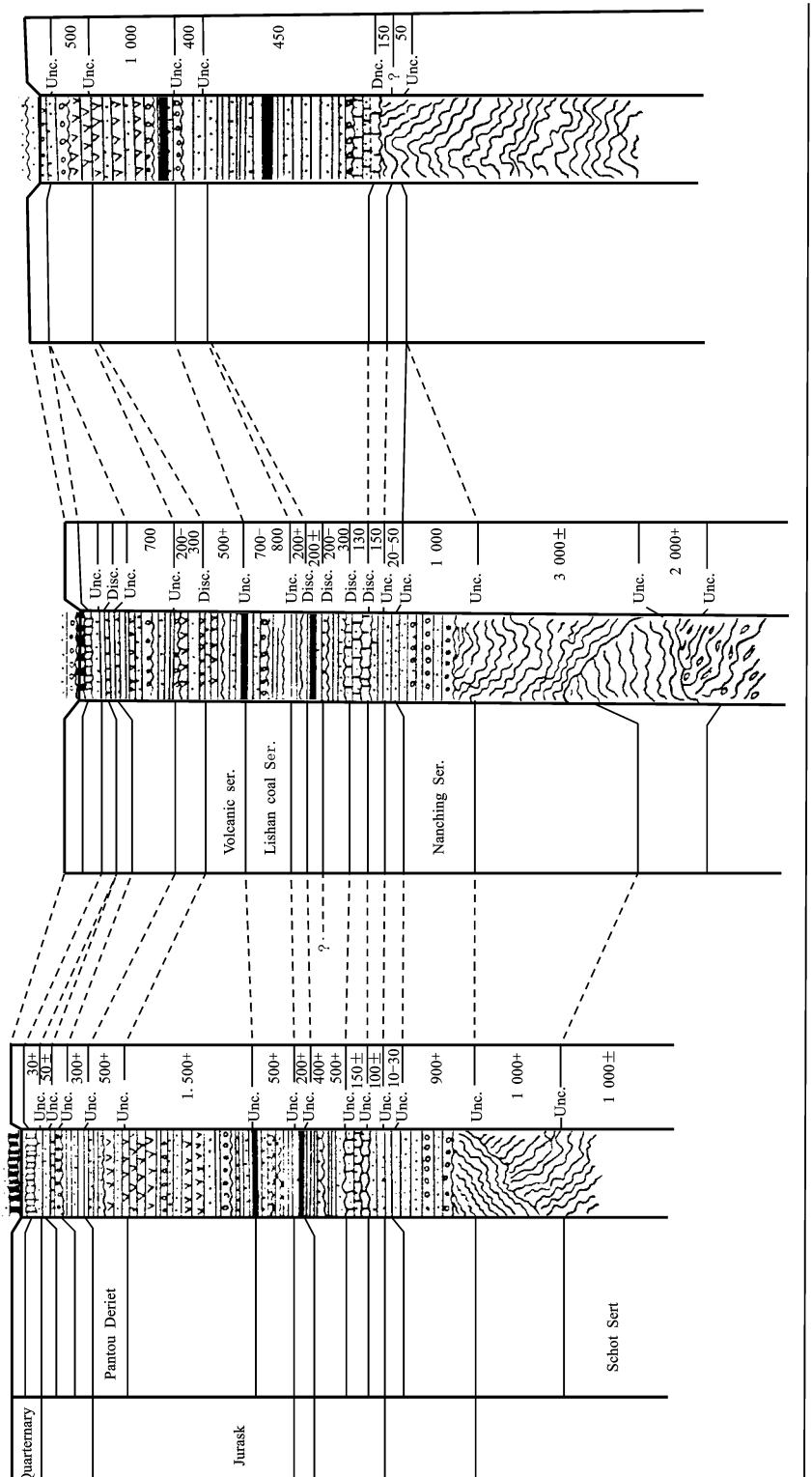


Fig. 1 Stratigraphical correlation between the regions of Northwestern Fujian(1), Southeastern Fujian(2) and Eastern Guangdong(3)

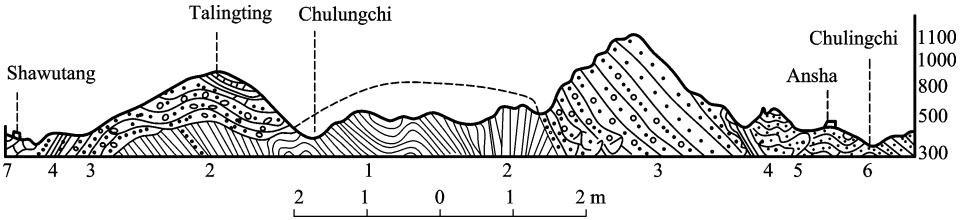


Fig. 2 Section from Shawutang to Ansha, Yungan, Fujian

1 – 2—Phyllite series (pre-Sinian); 1—Gray phyllite; 2—Greenish phyllite; 3 – 6—Nanching series; 3—Massive coarse quartz-conglometate; 4—Purplish phylite; 5—Quartzite and quartz-conglomerate; 6—Reddish quartzose sandstone and white sandstone (after Yang, 1944)

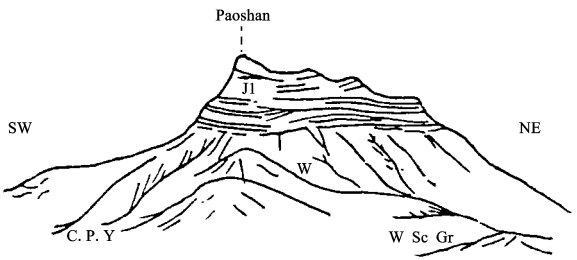


Fig. 3 Section showing the unconformable contact of the schist series with the Lishan coal series at Paoshan, Shunchang, Fujian

J1—Lishan coal series (sandstone); W—Schist series (mica schist); Gr—Muscovite granite (after Sheng, 1950)

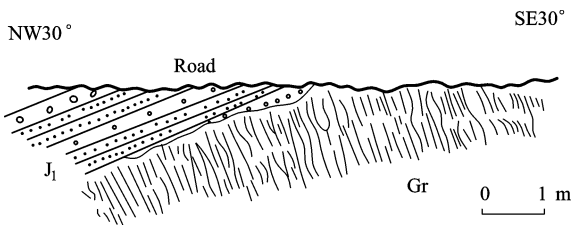


Fig. 4 Section showing the unconformity between the Lishan coal series (J_1) and the hornblende gneiss (Gn) (Pre-sinian), northern bank of Tangchi, N. W. of Chikouchich, Kienou, Fujian. (After M. K. Chern, 1941)

Geological investigations indicate that a regionally metamorphosed formation consisting largely of phyllites and quartzites occurs in various parts of South China. It is represented by the Liench'uan Series or the Shuangch'iaoshan Series in Jiangxi, and the Panchi Series in Hunan. This metamorphic formation is generally accepted as the equivalent of the Huto Series of North China. It is the main

constituent that forms the folded foundation of the South-China platform. According to the lithological characteristics and the stratigraphical position, the pre-Sinian phyllite-series of the southeastern coastal region may be correlated with the Linch'uan Series of Jiangxi. Obviously the folded foundation of the said region is but a part of that of the broad platform of South China.

At the end of the Lower Proterozoic, the main part of China emerged from the water as the result of the Lüliang movement (equivalent to Goto-Karelian of North Europe). It appeared as the vast Chinese platform. The folded foundation of the said region, composed of the pre-Sinian metamorphic rocks, was apparently formed at that time. Hence, the southeastern coastal region is reasonably referred to the southeastern portion of the Chinese Platform.

3.2 The Erosional Period of Lower Palaeozoic

There is no Sinian or Lower Palaeozoic deposit of any kind found in the main part of the region here under discussion. This indicates that nearly the whole area of this region was exposed in the air and under denudation in these periods. Although the other parts of the South-China Platform such as Hunan, West Guangdong and Northwest Jiangxi were again and again immersed in water, the most part of Guangdong and the whole part of Fujian still remained above the sea level.

3.3 The Formation of the Devonian and Carboniferous Continental Deposits

The deposition on the folded foundation of this region began in Devonian, but the first deposits are of continental origin. They are represented by the Nanching Series of Fujian. It is composed chiefly of quartzites 900 – 1000 m in thickness, unconformably lying on the pre-Sinian metamorphic rocks (Fig. 2). In the central-southern part of jiangxi occurs the Hsiashan Series (Chen, 1940). It has the similar lithological characters and stratigraphical position as the Nanching Series, containing at its uppermost part the Etroeugtian plant fossil *Sublepidodendron mirabile* (Nath.). It is believable that the Hsiashan Series as well as its equivalent the Nanching Series is from Devonian to Lower Carboniferous in age.

No Middle Carboniferous deposit has ever been proved to be present in this region except that some greyish white and yellowish brown shales of less than one hundred metres in thickness occur between the Nanching series and the Uralian beds as found in Shahsien, Fujian (Sheng, 1943). It was supposed to be the equivalent of the Tzushan coal series of Jiangxi, which furnish the typical Westphalian plant fossil *Neuropteris gigantea* Sernberg (Chen, 1940). No matter this is certain or not, the region here under discussion was a land at that time.

3.4 The Marine Transgressions with Its Corresponding Deposits and the Formation of the Marine and Non-marine Alternating Beds from Later Palaeozoic to Early Mesozoic

The Upper Carboniferous Chuanshan limestone is distributed widely in this region. This was the first marine deposit since the consolidation of the old land. However, in accordance with the smallness and uniformity of its thickness (being 30 – 50 m everywhere), it is nothing but a deposit lying on the broad and flat surface of a stable old land during the wide-spread transgression of the shallow sea. The unnoticed lateral changing of the lithological characters of this limestone indicates the same condition. In fact, the Chuanshan limestone that occurs in all the other parts of the South

China platform possesses this same peculiarity.

At the end of the Uralian Epoch, the southeastern coastal region of China once emerged from the sea, while in the early Permian period the sea transgressed again. The wide-spread Chihsia limestone resulting from this marine transgression, with its thickness only 150 m, is also but a shallow sea deposit on the flat surface of the old land.

After the Chihsai transgression, the old land emerged from the water again. From the upper part of Lower Permian to Upper Permian this region came to a period of alternation of transgression and regression of the sea. The result was the formation of the Wenpishan Series, the *Gigantopteris* coal series and the Tsuipingshan Series. The Wenpishan Series is the equivalent of the Kufung formation of Nanking Hills, while the *Gigantopteris* coal series and the Tsuipingshan Series are the representatives of the wide-spread Lopingian formation of South China in this region. The Wenpishan series, which consists of sandstones and sandy shales, 120 – 130 m in thickness and furnishes the cephalopods *Gastrioceras* and the brachiopods *Parenteletes*, *Chonetes*, *Schizophoria*, *Productus*, etc., indicates that this region was a shallow sea at that time. The *Gigantopteris* coal series is a continental deposit. The disconformity between these two series also shows the emergence of the land. After the deposition of the *Gigantopteris* coal series, the phenomenon of alternation of the advance and retreat of the sea was still more obvious. This was recorded by the Tsuipingshan Series which is composed mainly of shales and sandy shales intercalated with some thin-bedded sandstones, 200 – 250 m in thickness. There are in this series abundant fossils, both marine and continental, including *Gastrioceras* (Cephalopods), *Productus* (brachiopods), *Lobatannularia* (plant remains) and the semi-freshwater pelecypods such as *Carbonicola wangsoweni*, etc.

At the beginning of Triassic, the land submerged once more. The Chikou series which is composed of shales and sandstones intercalated with thin-bedded limestone, 250 m in thickness, is apparently a part of the wide-spread marine Triassic beds on the South-China Platform. It contains *Pseudomonotis*, *Meekoceras*, etc.

In short, from late Palaeozoic to early Mesozoic, marine transgressions did happen in the southeastern coastal region of China, but it was merely a shallow, wide-spread sea covering the flat surface of an old land. This may be proved by the lithological characters, the smallness of thicknesses, the stableness in rock facies and thickness in the lateral directions, and the plentifulness of the furnished fossils of the resulting deposits. Specially noticeable is the smallness of the the thickness of these marine beds. The total thickness of all of them, including even the Tsuipingshan series which consists of marine strata with intercalated continental beds, in only 640 – 730 m. This shows that the amplitude of the oscillation of the land was rather small. However, owing to the fact that the land surface of this region at that time was flat, even a slight subsidence would cause the sea to cover a vast area so that the marine beds with small thickness but extensive spreading were formed. In the next stage a slight upheaval would make the sea entirely retreated. This also produced the intercalated continental beds as well as the disconformities or even slight unconformities between the successive formations.

3.5 The Crustal Movements and the Magmatic Activities Since Middle Mesozoic

In the Middle Mesozoic period, the southeastern coastal region of China came to an entirely new stage in its geologic-historical development. As early as Late Triassic, the sea retreated completely from this region. Instead of the oscillating movement in small amplitude, the whole area of the region became arched as the result of "process of arcogenesis" or arcuation①(1953), so a series of linear, anticlinorium-like elevation extending generally in the NE-SW direction and intercalated with synclinorium-like depressing belt were produced. Immediately powerful erosion began. Accompanying with the progressing of the subsidence of the depressing belts, a great sequence of continental deposits with the total thickness up to 3 000 m were formed. These include the Rhaetic-Liassic coal series, the Juro-Cretaceous volcanic series, the Cretaceous Pantou series which furnishes the plant remain *Onychiopsis* and other fossils, the Tertiary Red beds and the Mengchi series (Figs. 5 – 8). The enormous Juro-Cretaceous volcanic series up to 1 000 m in thickness (Figs. 5, 6) indicates that volcanic activities were violent when the "arcogenesis" was in progress. Until early Cenozoic, the volcanic eruptions still happened as shown by the Tertiary basalt.

Beside the volcanic eruptions there were immense granitic intrusions at the end of Mesozoic (Fig 7,8). The wide spreading of the granite and volcanic rocks is the most typical peculiarity of the southeaster coastal region of China. According to C. S. Kao (1944), in Fujian the outcrops of the granite and volcanic rocks occupy 40% and 20% – 30% respectively of the area of the province.

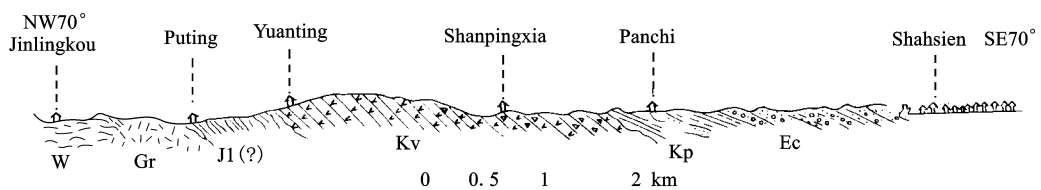


Fig. 5 Section across the western limb of the shahsien basin

W—pre-Sinian Schists and gneiss; J1—Rhaetic-Lias coal series. Gr—granite. Kv—volcanic series (Jurassic-Cretaceous) (middle part); Kp—Pantou formation (Creteceous); Ec—Chishih formation (Tertiary). (After Sheng 1950)

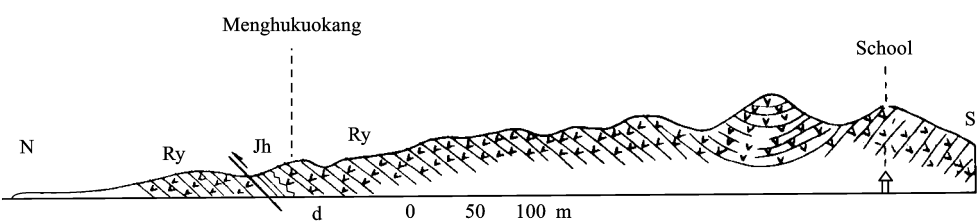


Fig. 6 Section of Hanshan, Ch'aoan, Wantung, showing the syncline and and the thrust

Ry—rhyolite, Jh—Hsiaoping coal series; d—disconformity (After Chang, 1944)

① Павовасний E. B. named it as "Процесс оркогенеза".

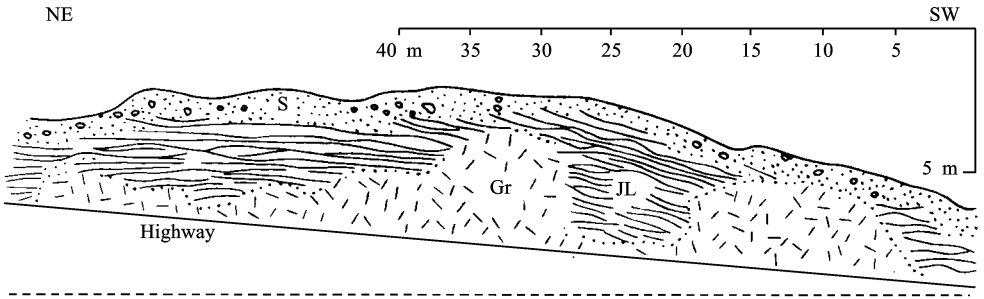


Fig. 7 A highway cut section at the western side of Sipeiling, showing the granite (Gr) intruded in the Lishan coal series (JL)

S—soil mantle (After M. K. Chern, 1941)

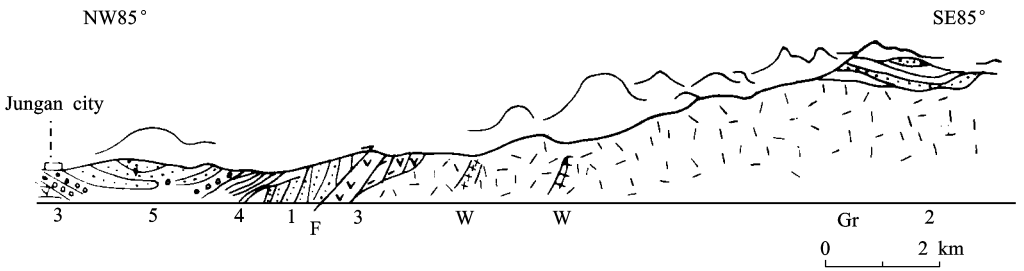


Fig. 8 E-W Section through the Jungan city, Fujian

1—Nangcheng series; 2—Lishan coal series; 3—volcanic series; 4—Pantou series; 5—Red Beds; Gr—granite; W—gabbro dike; F—Thrust

Strong crustal movements during the formation of the deposits in the depressing belts were recorded by the pronounced unconformities among the different strata of Mesozoic and Cenozoic.

4 Remarks on the Geotectonic Characteristics

To sum up all the facts mentioned above, we find that the geotectonic characteristics of the southeastern coastal region of China are as follows:

① It has a remarked folded foundation as all the common platforms do.

② The long period of erosion in Late Proterozoic and Early Palaeozoic shows the peculiarity of an old land. The continental deposits formed in Devonian and Early Carboniferous indicate the same fact.

③ Marine transgressions did happen in the later periods of Palaeozoic and Early Mesozoic. However, the sediments resulting from these transgressions of the sea are merely deposits of platform-type. They are entirely distinct from those formed in the geosynclinal regions.

④ Since the middle period of Mesozoic, the geological development of this region entered a new stage—the stage of "activization" of platform as B. B. Белоусов calls it (1955). The originally existing stableness of the land was substituted by the great activities. The process of "arcogenesis" or arcuation brought with it the new conditions of deposition. The continental sediments in great sequences, intercalated with numerous volcanic beds produced in the newly formed depressing belts, are quite different from the sediments found in a common platform, but similar to those appearing in the "secondary geosynclines" as stated by E. B. Павловский (1953). There generally occur a special type of sedimentary mineral deposits (chiefly of coal and oil shale), which have been named by the writer (1956) the "sedimentary mineral deposits of activizing-platformal depression-type". In addition, the presence of the immense acidic magmatic intrusions at the end of Mesozoic, which are generally typical exclusively to the geosynclinal regions, is still noticeable.

⑤ The folds produced during the Mesozoic crustal movements in this region have their own peculiarities. They are distinct both from those found in the ordinary platform and from those of the geosynclinal type. As indicated by B. B. Белоусов (1954) and other geotectonists, the folds may be classified into two main groups, namely, the "successive folds" and the "isolated folds". The former is prevalent in the geosynclinal regions while the latter is characteristic of the platforms. Between these two main groups, there is still an intermediate type which is generally found in the regions with intermediate geotectonic nature. As to the intermediate fold-type, two varieties have been recognized, namely, the "comb-like folds" and "the box-like folds". So far as we know, the folds developing in the region here under discussion after the pre-Sinian Lüliang movement mostly belong to the intermediate type (Fig. 9) (Kao, 1941).

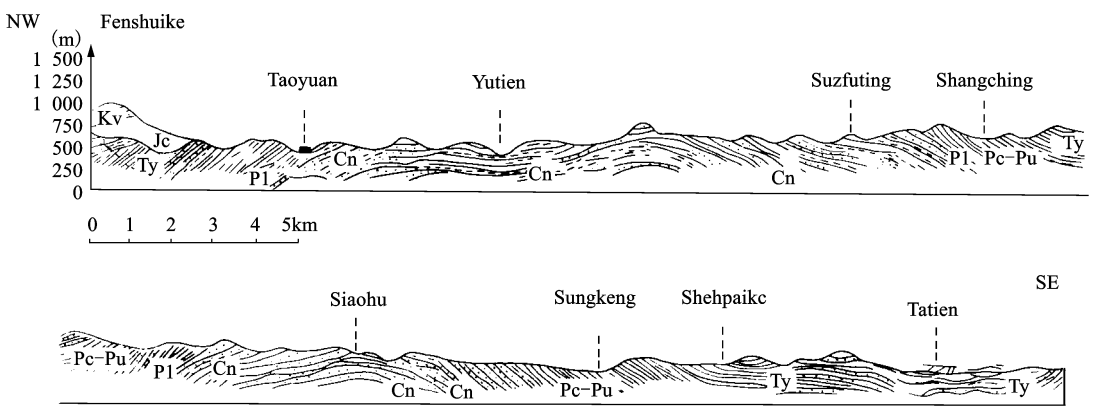


Fig. 9 Geological section along the highway between Taoyuan and Tatien, Fujian

Cn—Nacheng series (Devon-Carb); P1—Chihsia series (L. Perm.); *Gigantopteris* coal series (Up. Perm.); Ty—Yangping series (=Chikou series) (Trias.); Jc—Rhaetic-Liassic coal series; Kv—Cretaceous volcanic series; Gr—Granite. (After Kao 1941)

⑥ Until the recent geological period, the process of activization of the said region has not yet

ceased. This is proved by the presence of a famous earthquake zone occurring along the coast of Southeastern Fujian and Eastern Guangdong (Wong, 1923). Hot springs are widely spread in Fujian and Eastern Guangdong (Yok, 1932; Chang, 1835; Chang, 1949). Finally, the repeated upheaval and subsidence of the coast of South China in Quarternary (How, 1935; Ma, 1942 & 1947; Chen, 1951) also imply that the recent crustal movements of this region are not negligible.

5 Conclusions

To sum up, the southeastern coastal region of China originally was an old land. Although it has been again and again submerged by the sea, the resultant marine deposits are entirely different from the deosits of a geosynclinal region. In the middle of Mesozoic this region began to be active violently again, producing a series of depressing belts or "secondary geosynclines". In these belts thick continental beds, up to thousands of metres, have been deposited. At the same time, it was characterized by the formation of folds mainly of intermediate type. Besides, serious volcanic eruptions and immense magmatic intrusions were also typical of this region during the Mesozoic crustal movements. All these facts indicate that the geotectonic nature of the said region is distinct from both a geosynclinal region and a common platform. Thus to refer the southeastern coastal region of China to an "activizing" or "resurrected" platform is quite justified. Conspicuously it is one of the typical "activizing" regions of the vast Chinese Platform.

As to the nomination of this geotectonic unit, the writer proposes to call it the "Cathaysian activizing region". This name is derived from the "Cathaysia" old land of A. W. Grabau (1924) but it includes, according to necessity, the meaning of "activizing" or "resurrected" characters of this region. The so-called "Minchê Pacific folding zone" of A. C. Хоментовский (1953) is obviously unacceptable because it does not entirely coincide with the fact.

The northwestern boundary of the Cathaysian " activizing" region generally lies along the line starting from Central Zhejiang through southern Jiangxi to the southwestern part of Guangdong, because the history and characteristics of geological development of Southeastern Jiangxi and Central-Southern Guangdong are quite similar to those of Fujian and Eastern Guangdong. To the northwest of this boundary line is another " activizing" region, i. e., the "Zhejiang-Jiangxi-Hunan-Guangxi 'activizing' region" (Chen, 1956, 1957).

In comparison with the " activizing" platforms found in other parts of the world, the "Cathaysian activizing region" of the Chinese platform has its own characteristics, especially shown by the presence of numerous, widely spread, small depressing belts or "secondary geosynclines" and the acidic magmatic activities appearing in a large scale. All these indicate that this is a special type different from all the known "activizing" platforms. It may be called the "Cathaysian type of activizing platform" as proposed by the writer (1957).

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Process of Cathaysian-Type Platform Activation*

Cathaysian-type platform activation is one of the most widespread types of platform activation in the world. In eastern Asia it developed in the east of the Chinese Platform and the east and south of the Siberian Platform. It is characterized by formation of a series of small "activated platform depressions".① and significant magmatic activity[1]. It is necessary to discuss its process in order to know platform activation of this type more clearly.

1 Period Division

The process of Cathaysian-type platform activation can be divided into four periods based mainly on the study of various activated regions in the Chinese Platform.

(1) Initial-mobility period: At the beginning of platform activation, arcogenesis[2] disturbed the original flat topography of a platform and formed a series of linear domes and intervening depressions, "activated platform depressions". As a result, erosion became intense and new rock-forming conditions appeared; a lot of clastics migrated from uplifts to depressions where they were deposited. These "sediments deposited in the initial-mobility period of platform activation" consist mainly of coarse rocks (conglomerate, breccia, gravelly sandstone and gritstone) and constitute the basal conglomerate common to most "sediments of activated platform depression type"②

(2) Gradual advance period③: Arcogenesis continued to proceed, activated platform depressions continued to deepen, and sediments deposited in them continued to thicken. Tectonic movements often became intense and hence the rate of subsidence increased and sometimes folding occurred. Therefore, sedimentation was frequently interrupted and unconformities (or disconformities) resulted. In some places there were magmatic activities which occurred as volcanic eruption or magmatic intrusion. Sediments deposited in depressions at this stage contain more fine clastics, and sometimes limestone might be formed, but conglomerate or gritstone were still intercalated or seen at the bottom of sub-strata separated by an unconformity or disconformity. In places where volcanic activity occurred, sedimentary rocks contain volcanic detritus or volcanic intercalations.

(3) Maximun-mobility period: Tectonic movements and magmatic activity came to a climax.

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① Renamed as "diwa" and "diwa-type sediments" by the author in the papers published after 1959.

② Renamed as "diwa" and "diwa-type sediments" by the author in the papers published after 1959.

③ This period was merged into the "initial-mobility period" in the papers published after 1961.

Sediments continued to thicken. In places where volcanic activity occurred, sediments contain numerous volcanic detritus and volcanic intercalations. Magmatic intrusion occurred widely and affected all the strata formed in this period and before. Folding took place intensely and disturbed the strata formed in this period and before and resulted in open folds (box and comb-shaped folds). Sometimes overturned folds, recumbent folds and overthrust faults occurred. Consequently all of the sediments deposited in depressions were uplifted to form mountains. Affected in the same way by the folding movement occurring in this period, the sedimentary cover of the original platform also took part in the formation of the mountains. These mountains have an almost linear shape and similar to "geosynclinal fold belts" (or "fold belts" for short). But in fact, folds making up the mountains are brachy-axis, "quasi-linear folds", not long-axis, holomorphic, real linear folds. That is the reason why the author called the mountains "quasi-linear mountains" and the fold belts represented by them "activated platform fold belts"① as distinct from geosynclinal fold belts.

(4) Residual-mobility period: New depressions emerged between newly formed "activated platform fold belts", or the original depressions or their segments continued to deepen. At that time, the difference in height was large and erosion and sedimentation were violent. Therefore, sediments deposited in the "depressions of the residual-mobility period" were similar to those deposited in the depressions of the initial-mobility period, i. e. characterized by extraordinary development of clastics. The amplitude of subsidence of these depressions was less than that of the depressions formed before, and hence the thickness of sediments was smaller. But sometimes thick sediments may be laid down in this period. Depressions of the residual-mobility period may be compared with intermontane depressions in a geosynclinal fold belt in terms of process of their formation and features of their sediments. These depressions have been called "intermontane depressions of activated platform fold belt"②. In this period, magmatic activity reduced and tectonic activity became weak. But tilting, flexures, gentle folds and small-scale overthrusts still occurred; block-faulting was extensive.

No hard and fast line can be drawn between the above-mentioned four periods. Transition from one period to another occurred not along a straight line, but progressively and irregularly, especially beween the initial-mobility and the gradual advance period, and between the gradual advance and the maximum-mobility period.

2 An example of period division

In order to illustrate the process of Cathaysian-type platform activaton, we take one of the activated regions in China as an example (Table 1).

① Renamed as "diwa fault-fold belt" in the papers published after 1959.

② Renamed as "intermontane depression" and "sediments of interrnontane depression" in the papers published after 1959.

Table 1 An example of Cathaysian-type platform activation

tectonic stage		geologic age	sediments	magmatic rocks	tectonic movements
stage of platform activation	residual-mobility period	Quaternary	alluvium, gravel, sand and mud		up-and-down movements
		Tertiary	Qujiang Formation: shale, gravelly sandstone and basal conglomerate 600 m thick	basalt	
	maximum-mobility period	Cretaceous-Jurassic	Bantou Formation: conglomerate, shale and sandstone, 1000 m thick		folding movements
			Tiaoling volcanic complex: rhyolite, purple sandstone, shale and conglomerate interbedded with a lot of numerous volcanic rocks 3000 m thick		folding movements
	gradual advance period	Lias-Rhaetic	Lieshan Formation: total thickness 800 m. Upper and middle parts: sandstone, shale, gravelly sandstone and coal. Lower part: mainly conglomerate		folding movements
	initial-mobility period				
stage of platform-type tectonic movements		Early Triassic	Xikou Formation: marfine shale and limestone		arcogenesis and folding movements

3 Conclusions

The author[3] has pointed out that platform activation plays an important role in mineralization. In the case of Cathaysian-type platform activation, the resultant mineral deposits can be divided into endogenic deposits produced by "magmatic activity of activated platform type"① and exogenic deposits produced by "sedimentation of activated platform depression type"①, The former includes nonferrous and rare metal deposits associated with voluminous granite (and other intrusive rocks) and those associated with volcanic rocks such as rhyolite and tuff. The latter is distinctive "sedimentary mineral deposits of activated platform depression type"①. including coal, oil shale and salts[4]. In terms of the period of platform activation, mineral deposits produced by magmatic activity of activated platform depression type formed dominantly in the maximun-mobility pcriod, and seldom in the gradual advance and the residual-mobility period. Sedimentary mineral deposits of activated platform depression type may have formed in any period of platform activation, but mostly in the gradual advance and the residual-mobility period. This is probably because tectonic movements in these two periods occurred gently, which could be favourable for some mineral deposits (such as coal). It is undoubted that the formation of these sedimentary mineral deposits was related to climate and other factors as well as tectonic factors. The influence of climate upon the kind of minerals was particularly evident. For example, the initial-mobility and gradual advance periods (Lias-Rhaetic) of platform activation in South China were under a damp and hot climate and hence saw many coal fields. But in the maximum and residual-mobility periods (from end of Jurassic to Paleogene) the climate became hot and semi-arid and favourable for the deposition of red beds, and therefore gypsum and rock salt were laid down.

In accordance with the intensity of volcanic activity in the process of platform activation, Cathaysian-type platform activation can be classified into two basic styles. One is "Fujian-Zhejiang style" which has significant volcanic activity. The other is "Hubei style" which has no or insignificant volcanic activity[1,3]. This classification of Cathaysian-type platform activation is most evident for the maximum-mobility period, but less for other periods. For example, the red beds in southeastern China, according to the author[4], can be divided into the Cretaceous old red beds and the Paleogene new red beds. In the eyes of lithology, thickness and disturbance by magmatic activity and tectonic processes, these red beds are all sediments of activated platform depression type①. Of them the old red beds were deposited in the maximum-mobility period of the activation of the South China platform, while the new red beds were sedimented in the residual-mobility period (i. e. deposited in the intermontane depressions of an activated platform fold belt). Moreover, The old red beds can be subdivided into two styles based on the presence or absence of volcanic materials:

① Renamed as "diwa-type magmatic activity", "diwa-type sedimentation" and "diwa-type sedimentary mineral deposits" in the papers published after 1959.

coastal style containing abundant volcanic materials and Jiangxi-Hunan style poor in volcanic materials[4]. The former covers an area equal to the region affected by Fujian-Zhejiang style platform activation, while the latter, by Hubei-style platform activation. But the new red beds laid down in the residual-mobility period do not show such a difference.

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The Third Basic Tectonic Element of the Earth's Crust—the Diwa (Geodepression) Region*

Editor's note

This is the first paper concerning the diwa theory published during the "replenishment period" of the theory. When the paper *Examples of "Activated Region" in the Chinese Platform with Special Reference to the "Cathaysia" Problem* was published in 1956, the author considered the third tectonic element of continental crust only as the result of activization (activation) of platform, i. e. the result of transformation of a platform region into a mobile region, and called it an "activated region". Later the author recognized that the term could only reflect the historical setting and the progress of the formation of the tectonic element, but not the main characteristics, and that it was difficult to use it as a distinct mark. Further study indicated that a "stable" region is not of only one type as well as a mobile region. In the history of the evolution of the crust, there existed a "stable" region before the appearance of the geosynclinal region (see *Pre-Sinian Tectonics*). In addition, not only the platform region but any other kind of "stable" region may be activated. For example, the geosynclinal region is the result of activation of a pre-geosynclinal "stable" region. So the term "activated region" seems to be general, and can not indicate exactly that it is a post-platform new-type mobile region. Although the term suggested by the author had gradually been accepted widely by many geologists in China and other countries (later some Soviet geologists, e. g. Shcheglov (1968), extended the meaning of the term and introduced some concepts such as "region of tectono-magmatic activization"), the author thought it necessary to introduce a more exact term instead of the general one, which was what made the author write this paper. The third tectonic element is characterized by a widespread intermontane structural basin called "diwa" (geodepression, originally named activated platform depression), which is an important criterion for its identification. Therefore, the region was called a "diwa region". The term is now used as a synonym of "activated region" in the geological literature of China and other countries.

The following is the main theses and significance of this paper. The paper summarized some research achievements which had been strengthened and systematized gradually during the first development period—"initial period" of the diwa theory. Besides the terms "diwa" and "diwa region" proposed, the term "sediments of activated platform depression". as had been called before, was renamed as "diwa sediments" or "diwa-type sediments". The. third structural layer ("activated structural layer" as had been called before) composed of these sediments was called a "diwa sedimentary layer"①.

The paper further indicated clearly the nature of the diwa region and its position in the history of crustal evolution. It is the third tectonic element following the geosynclinal and the platform region and is a new-type mobile region with more complex construction.

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① Renamed as "diwa structural layer" by the author in the papers published after 1959.

The paper introduced the term "diwa-type mineralization", for the first time, as the synonym of "activation-type mineralization" to reflect more exactly the characteristics of this type of mineral deposit and rnetallogenie regularities. The Chinese "地洼" is translated into English as "diwa"① according to the Chinese phoneticism or "geodepression" according to the meaning. In the Soviet Union it is spelled as "дива". The term was first introduced into the Soviet Union by Soviet geotectonists. In Japanese geological literature it is written as "地洼" directly from the Chinese words.

There were only two basic tectonic elements of the Earth's crust having been recognized before, i. e. the geosynclinal and the platform region. The former is a mobile region while the latter a "stable" one. In any platform region, there is always a folded basement (the lower structural layer), which was formed from geosynclinal-type sediments through complex tectonic changes, magmatic activity and metamorphism. On the folded basement lies a sedimentary cover (the upper structural layer), consisting of platform-type sediments, which had undergone little tectonic changes and weak magmatic activity, and from which metamorphism can hardly be seen. Therefore, we may conclude that the platform region was formed as a result of transformation through "stabilization" of a geosynclinal region.

The research on platform activation has proved that the crustal sector in which a platform region lies would gain a highly strong tectonic activity after a long or short "stable" stage. This sort of activity goes evidently beyond the category of platform-type crustal movement, and changes the platform region into another type of tectonic region[1]. This new tectonic region, different in nature from either a geosynclinal or a platform region, has the following features.

First, in construction, this new tectonic region has three structural layers. The first and second structural layers are composed respectively of geosynclinal-type sediments which had been subjected to strong folding, magmatic activity and metamorphism, and of platform-type sediments which overlie the geosynclinal sediments. Evidently these two structural layers were originally the folded basement and the sedimentary cover of the ancient platform in the region. As for the "third structural layer", it is a new and specific one, different from either the first or the second. It consists of depression-type sediments (also called "sediments of the third type") which have a molassoid formation as their peculiarity and a continental clastic rock as their main component. The molassoid formation in these depression-type sediments emerged in an ancient platform region, in no connection with the development of any geosyncline. Furthermore, these sediments are frequently influenced by strong magmatic activity and sometimes have many interbedded volcanic products. These features indicate that the sediments are different from other depression-type sediments deposited in foredeeps and intermontane depressions and characterized by a true molasse formation. In fact, they were formed in the depressions that appeared in the original platform region during platform activation and that had deep sinking as their main feature. Since this special kind of depression is called diwa (a Chinese

① In some literatures it is translated as "tiwa", "tiva" or "diwa". They have the same meaning.

term which means "geodepression"), these peculiar sediments are called "diwa sediments", and the "third structural layer" consisting of them is called "diwa sedimentary layer". Besides, as it resulted from platform activation, it is also called "activated structural layer". It is significant for the third structural layer to be recognized and studied, for it shows one of the main features of the new tectonic region that has been formed from the platform region as a result of transformation. It therefore can serve as an important criterion for distinguishing the new tectonic region from the platform one.

Secondly, tectonic movements in the new tectonic region formed through platform activation are more evident than in the platform region. Folds formed during these tectonic movements are mainly of open type, but occasionally of tight or nearly tight type. In addition, there are also faults and sometimes overthrusts. These structures are found only in the third, but also in the second and even in the first structural layers.

Thirdly, magmatic activity in the new tectonic region is apparently different in intensity and scale from that in the geosynclinal region. The new tectonic region is rich in granites and other acid rocks accompanied by well-developed volcanic rocks. These products of magmatic activity may exert an influence on the third, second and first structural layers. The difference in magmatic activity between the new tectonic region and the geosynclinal region lies in the fact that the former accompanied (or occurred at the same time as) diwa-type other than geosynclinal-type sediments. In addition, magmatic activity in the new tectonic region occurs in sequence from acid to basic rocks, while that in the geosynclinal region has a reversed sequence.

Finally, the new tectonic region is also different in relief from the platform region. Relief in the former is high and shows itself mostly as quasi-linear mountains, while that in the latter is low and shows itself as plains or peneplains, Neotectonic movements are mostly notable: besides rising, sinking, faulting, monoclining and warping, there are sometimes arching and folding. From the above discussion, we may conclude that the new tectonic region, formed through platform activation, is a mobile region. It is not only different from the platform region which belongs to "stable" regions, but also different from the geosynclinal region which, as the new tectonic region does, belongs to mobile regions. Therefore, it can be taken as neither a platform nor a geosynclinal region. In construction, it is more complex and has a more advanced form than the platform region with two structural layers, not to mention the geosynclinal region with only one structural layer composed of geosynclinal-type sediments. Its other features are not the same or not completely the same as those of either the platform or the geosynclinal region.

The complexity of the construction of the new tectonic region and its comparison with the two previously known basic tectonic elements, especially the relationship between the first and second structural layers and the folded basement and sedimentary cover of the platform region substantiate that the new tectonic region, formed through platform activation, is a new mobile region transformed in the process of crustal evolution from a platform region, after the stage in which the geosynclinal region, a mobile region, is transformed into the platform region, a "stable" region. This new-

tectonic region, having overthrown the form of its preceding region (the platform region, a "stable" region), has inherited the basic contents of this preceding region as its own components, that is, has taken the upper and lower structural layers of this preceding region as its first and second structural layers. In addition, it has new and peculiar components of its own (the third structural layer, or "diwa sedimentary layer"), thus changing the region into a new basic tectonic element with a form more advanced than that either of a geosynclinal or a platform region. This region is neither of "intermediate type" between geosynclinal and platform types, nor a "platform with stronger tectonic activity" or the so-called "paraplatform", as some people mistakenly regarded. Rather, it is the third basic tectonic element which represents a new form of crustal evolution and is equal in status to geosynclinal and platform regions. It is called a "diwa region", for its main features are "diwa (geodepression)" and "diwa sediments" constituting the "third structural layer". In 1956, when the author first recognized this new tectonic element, it was once called an "activated region", for it is the product of platform activation.

The discovery, understanding and elucidation of the "third basic tectonic element" have enabled us to have gone beyond the limit of the old idea that there are only two basic tectonic elements in the earth's crust. As a result, we have got a new understanding of the laws governing crustal evolution, and hence recognized a new type of mineralization, diwa-type mineralization (platform activation-type mineralization)[2]. This has pointed out a new way for insight into the regularities governing ore distribution and for ore prospecting.

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The Third Structural Layer of the Diwa Region—the Diwa Sedimentary Layer*①

The diwa region is the third basic tectonic element of the earth's crust transformed from platform activation,[1] One of its features is that it has more complex construction and higher form than those of the geosynclinal or platform region[2]. It not only contains the folded basement and sedimentary cover inherited from its predecessor, the platform region, as its first and second structural layers, but also adds to itself a specific third structural layer overlying them(Fig. 1). As a mobile region, it exhibited strong tectonic movements and magmatic activity during the deposition of this "third structural layer".

The third structural layer of the diwa region was formed of "diwa-type sediments" deposited in "diwa" in the process of its growth, i. e. in the period of platform activation. Diwa-type sediments are a basic strata group. They are different either from geosynclinal or from platform-type sediments and represent one of the important stratigraphic indicators of a diwa region. In most cases diwa-type sediments occur not in a large area as platform-type sediments do. They usually appear in rows, have a shape of an elongate strip and systematically scatter on the first and second structural layers. This indicates that they were deposited in diwa basins separated by "geodomes" and arranged in a definite direction and system. They are commonly very thick, generally a few thousand, and seldom over ten thousand m. But the thickness is greatly variable. This is true whether in diwa regions of different types or in diwa regions of the same type and whether in different diwa basins or in different parts of a diwa. This abrupt variation in thickness manifests itself remarkably whether in each single bed of diwa-type sediments or in the whole basic strata group composed of diwa-type sediments. Therefore, diwa-type sediments are evidently different from platform-type sediments marked by persistence. As regards lithofacies, diwa-type sediments are mainly continental (lacustrine and fluviatile) water-laid sediments, with local intercalated eolain and seldom marine sediments. As for rock types, continental rocks are dominated by clastic rocks such as sandstone, shale and conglomerate with minor amounts of limestone, while marine rocks include limestone and shale (Fig. 2). The above-mentioned continental clastic rocks alternate between coarse and fine clastics and form a molassoid formation. These continental depressional sediments characterized by a molassoid formation were laid down on an ancient platform and had no relation to the development of any geosynclinal region. They generally contain interbedded volcanic materials locally (Fig. 3). Therefore, they are different from the similar sediments of foredeeps and intemontane depressions.

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① Renamed as "diwa structural layer" by the author in the papers published after 1959.

Diwa-type sediments are greatly and abruptly variable in lithotogy and hence markedly differ from platform-type sediments in this aspect. Finally, diwa-type sediments have many hiatus which are marked in most cases by unconformities (different from disconformities appearing in platform-type sediments). Therefore, they are often divided into many stratigraphic units with variable thickness.

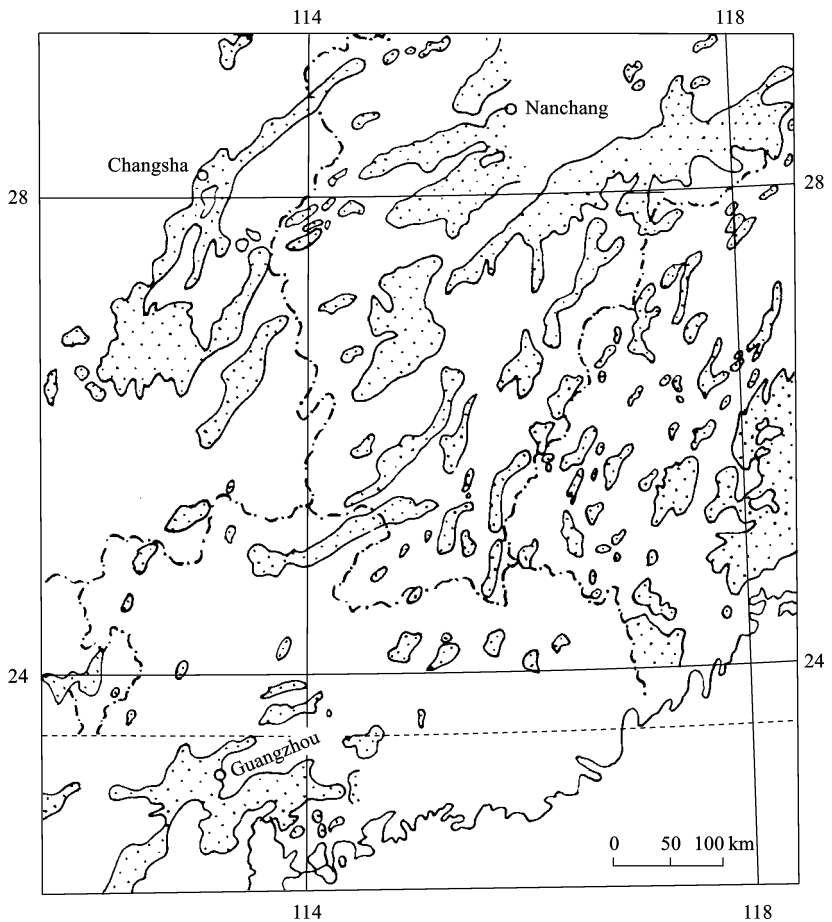


Fig. 1 Distribution of the diwa sedimentary layer in southeastern China showing its scatter in small pieces but arrangement in a system.

The third structural layer of a diwa region has undergone considerable folding, thrusting and faulting. Folds are mostly of open type, such as arch and comb-shaped folds. Tight or almost tight folds can seldom be observed. These structures are different from weak, gentle and predominantly discontinuous folds seen in the sedimentary cover of a platform region. However, they can also be found in the second and even in the first structural layer of the same diwa region.

The third structural layer of a diwa region contains volcanic intercalations, volcanic materials and voluminous intrusive rocks. This is evidently different from that seen in the sedimentary cover of a platform region. In a diwa region magmatic activity produced mainly acid rocks. Here magma

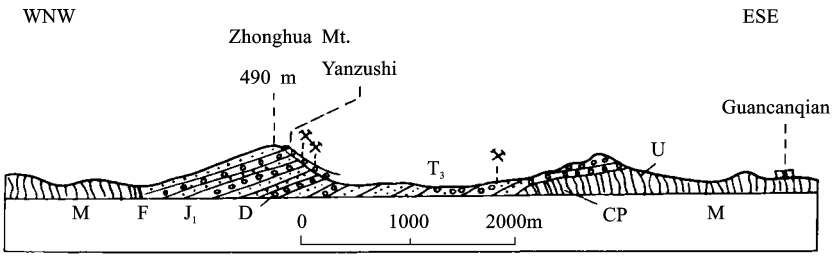


Fig. 2 Cross section from Zhonghua Mt., Chongren County, to Guancanqian, Yihuang County, Jiangxi Province, in the center of the Cathaysian diwa region.

Strata constituting the diwa sedimentary layer: T = Liboqiao Formation (upper part of upper Triassic composed of basal conglomerate, sandstone, shale and interbedded coal, about 500 m thick); J—Chongren Formation (lower Jurassic composed of conglomerate, sandstone and interbedded shale and coal, about 800 m thick); F—fault; U—unconformity; D—disconformity; M—geosynclinal structural layer composed of phyllite and sandstone.

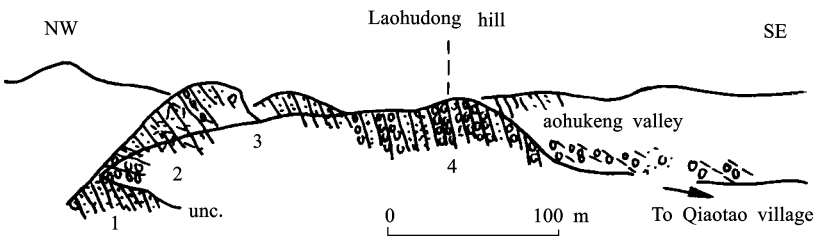


Fig. 3 Cross section North of Qiaotou Village, Yutu County, Jiangxi Province, in the center of the Cathaysian diwa region.

1—Devonian Xiashan formation (platform structural layer); 2 – 4) lower part of the Cretaceous old red beds (diwa structural layer); 2—basal conglomerate; 3—purplish red shale, sandstone, ash sandstone and ash conglomerate; 4—conglomerate and interbedded ash conglomerate, with big gravels.

evolved mostly from acid to basic. Therefore, the sequence of magmatic evolution in a diwa region is different from that in a geosynclinal region. Magma may have also intruded into the first and second structural layers of the same diwa region.

Tectonism and magmatism may have resulted in local metamorphism of the third structural layer of a diwa region. The third structural layer of a diwa region contains "diwa-type sedimentary mineral deposits", including coal, oil shale, bauxite, iron, manganese, salts, diatomite and refractory clay. In places where it has been affected by diwa-type magmatic activity producing intrusive or eruptive rocks, it also contains nonferrous, rare and scattered metals, iron, fluorite, pyrophyllite and aluminite.

The third structural layer is one of the important criteria for identifying a diwa region. As it is composed of diwa-type sediments, it has been called "diwa sedimentary layer". Moreover, as it is a

product of platform activation, it has also been called "activated structural layer". The recognition and elucidation of the third structural layer of a diwa region are essential to the knowledge of this new tectonic element of the earth's crust and the laws governing the distribution of mineral deposits and to the understanding of the laws governing crustal evolution and the laws governing metallogenic processes. However, in the past we did not pay attention to this important structural layer and the strata making up it. We either mistook them as platform-type sediments and hence as part of the sedimentary cover of a platform region without drawing a distinction between them, or put them into immaterial "local sediments" without taking them into consideration. This is one of the major reasons why the geological history and tectonic nature of many regions, such as a few areas in eastern China, can not be deciphered for a long time.

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A New Criterion for the Classification of Tectonic Regions—Crustal Construction*

In classifying tectonic regions, people used to emphasize the features of sediments, structural deformation, magmatism and relief, but not to notice the process of crustal development and the tectonic stage division in a region, so that the tectonic nature of some regions have remained unresolved for a long time. This has impeded us to recognize new basic tectonic elements.

The effective method to designate tectonic regions is the historical analysis method. It is the concrete application of dialectical materialism to tectonics. First, we must consider all features which occurred in the same stage of crustal development in a region instead of only one feature to be used separately as a criterion. Secondly, we must relate the features of different tectonic stages in a region to each other instead of seizing on fragments of facts in a certain stage as a basis for analysis. Thirdly, it is necessary for us to put in order the features of different periods in geological history according to their sequence and take these as the basis for stage division, as the features of different tectonic stages reflect the qualitative change of things.

In order to correctly decipher the geological history of a region and truely reflect the regularity governing crustal development in tectonic regionalization, the author, on the basis of his practical experience, has introduced a new criterion—"crustal construction" in using the historical analysis method.

By "crustal construction" we mean the number of "basic structural layers" ("structural layers" for short) composed of their own distinct "basic strata groups".

The "basic strata group" is the major association of strata which belongs to the same sedimentary type and has undergone crustal movement and magmatism of the same type. The number of sedimentary types in a tectonic region indicates the number of basic strata groups; the number of basic strata groups in turn indicates the number of structural layers of completely different nature. A tectonic region with more structural layers has a more complex crustal construction and higher-grade form, otherwise it has a rather simple crustal construction and lower-grade form. Simple crustal construction is typical of the basic tectonic elements which occur in earlier stages in the history of crustal development and have primitive forms, while complex crustal construction is the mark of those which occur later and have higher-grade forms.

This new criterion has been suggested on the following grounds. First, basic tectonic elements of different nature are different from but related to each other. They differ from each other in the

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complexity of development history, in the number and nature of basic strata groups constituting corresponding structural layers. On the other hand, they transtorm one by one and replace each other in a certain sequence and direction. A transformation results in a structural layer. Therefore, the number of structural layers in a tectonic region is variable in accordance with the time of occurrence of the corresponding basic tectonic element in the history of crustal development. Structural layers are fewer in the basic tectonic element occurring earlier, otherwise more. Secondly, different stages in the development of the same tectonic region are also different from but related to each other. This relationship reflects the process and sequence of successive transformation and mutual replacement of basic tectonic elements of different nature. Every stage has its own characteristics. It abandons the form of the preceding stage but inherits its basic contents as its components, with the addition of new components peculiar to itself. Any stage is so formed progressively through transformation.

It was thought in the past that there are only two basic crustal tectonic elements, namely, geosynclinal and platform regions which belong to mobile and stable regions respectively. Through the study of platform activation we have discovered that there are in fact more than two basic tectonic elements. So far as we know, there is still a "third basic tectonic element", namely, "diwa (geodepression) region" which is the result of the transformation of a platform to a mobile region. The geosynclinal region occurs earliest, the crustal construction of which is simple. It has only a single basic strata group composed of geosynclinal-type sediments. Therefore, it has only one structural layer and a low-grade crustal construction. The platform region, transformed from the geosynclinal region, inherits part of the geosynclinal fold belt preserved from peneplanation as the folded basement (lower structural layer), and gets a new structural layer— "sedimentary cover" (upper structural layer) composed of a basic strata group belonging to platform-type sediments. Therefore, it has a two-storeyed crustal construction, showing a more sophisticated and higher-grade form than the geosynclinal region. The diwa region, transformed from the platform region, inherits the upper and lower structural layers of the platform as its first and second structural layers, and gets a "third structural layer"—diwa sedimentary layer" (or "activated structural layer") composed of another "basic strata group" belonging to diwa-type sediments. Therefore, it has three structural layers, and is the most sophisticated and highest-grade one of the three basic tectonic elements known by now.

The author thinks it is necessary to collect the following eight aspects of informaiton in designating tectonic regions by using the historical analysis method: crustal construction, paleogeography, structural deformation, magmatism, geomorphology, neotectonic movements and mineral deposits. Consideration of the difference between basic tectonic elements in crustal construction has the following significance. First, it reflects the essential difference between tectonic regions of different nature, their transformation relationship and the sequence of their occurrence in the history of crustal development and thus helps us to determine which kind of basic tectonic element they belong to. Secondly, it makes it possible for us to recognize the complexity of the

process of geological development of a region and the features of different stages, and thus helps us tp decipher the metallogenic history of the region and to recognize the regularities governing the distribution of minerals. But using the criterion "crustal construction" to determine the tectonic nature of a region does not mean that it could be isolated from other criteria. On the contrary, it has combined the features of other main aspects and reconstructed the history of geological development of a region according to the sequence of the stages, and thus leads to a correct conclusion about the tectonic nature of the region concerned.

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Theory of Progression with Transformation Between Mobile and Stable Regions—A New Recognition of the General Regularity in Crustal Development*

Editor's note This is another important paper following the introduction of the third tectonic element, the diwa (1959) or activated (1956) region, by the author in the replenishment period of the development of the diwa theory. In this paper the author puts forward a new idea on the general regularity in crustal development, He believes that the platform region is transformed from the geosynclinal region, a mobile region, through "stabilization", while the diwa region is converted from the platform region, a "stable" region, through "mobilization" (activation). Therefore, a mobile region and a "stable" region are interchangeable. The difference in construction of various basic tectonic elements indicates that the transformation is a progressive movement, with the tectonic element formed by an earlier transformation being more complex in construction and higher in level than the tectonic element formed by a later transformation. Crustal development is the mutual transformation between mobile and "stable" regions according to the law of "negation of negation". Following a spiral, upward course, the crust develops ceaselessly from a simple to a complex form and from a lower to a higher stage. This is called the law of progression with transformation between mobile and "stable" regions. The law proposed by the author theoretically adds a new illustration to the dialectics of nature and gives a new explanation for the formation and distribution pattern of mineral deposits.

1 Introduction

In this paper, the regularity governing crustal development is approached on the basis of the concept of "platform activation" formulated by the author in last years. Here, the author's ideas are only preliminary, and conclusions remain to be drawn in future. The regularity governing crustal development is a vital problem, which can be solved well only by relying on collective effort and cooperative study of geologists. To cast a brick to attract jade, my humble opinions are posed for reference only.

2 Discussion of the Geosyncline-Platform Theory in the Light of Modern Geotectonics

Before the concept of diwa (geodepression) is posed, the known basic tectonic elements of the earth's crust are only two, i. e. geosynclinal and platform regions. The former is a mobile region and

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the latter "stable" region①. It has been suggested that the platform region is a region transformed from a geosynclinal region due to consolidation and "stabilization". Every platform must have a folded basement. The basement was originally made up of geosynclinal-type sediments. They have been disturbed by complex structures such as tight folds and accompanying faults and have been intruded by large-scale magmatic activity of geosynclinal type and have still been inflicted by intense metamorphism (2). This fact indicates that a geosynclinal region belonging to mobile regions will transform into a platform region belonging to "stable" regions whenever consolidation and "stabilization" take place in the process of crustal development. This recognition has gradually been shaped into a concept of the regularity governing crustal development. It is considered that crustal evolution goes from a geosyncline to a platform, i. e. from a mobile to a "stable" region. This concept is called "geosyncline-platform theory". The geosyncline-platform theory was first posed by Edward Suess. Afterward, the theory was developed by E. Haug and L. Kober. In the past years, the theory was always used as the main theoretical basis for general geotectonics, regional geotectonics, regional geology and historical geology. According to the theory, some geologists further considered that the process of crustal development could be divided into three basic stages. The first stage is named the "pangeosynclinal stage" appearing in the "Precambrian". At the end of the stage, platform regions appeared locally, which were separated by extensive geosynclinal regions and were comparatively small in area. The second stage which lasted 500 – 600 Ma from the late Proterozoic to the end of the Alpine orogeny was characterized by that platform regions were expanding at the expense of geosynclinal regions. The third stage is named the "panplatform stage", which lacks orogenic movements after the Alpine orogeny. Obviously, these geologists regard platform regions as the last stage of crustal development. They consider that at present the earth's crust is already stable as if man got into old age with scleroma and paralysis on his body (part of the paragraph quoted from E. V. Pavlovsky).

In the light of modern geotectonics, the geosyncline-platform theory has not fully expressed the process of crustal development and its regularity. Its deficiency is that it neglects such an important fact: many regions after a "stable" platform stage underwent rejuvenation, and the rejuvenation in some regions has been lasting even to the present time. The fact shows that the idea that crustal development only implies the conversion of a geosynclinal into a platform region and the present stage is the "panplatform stage" lacking orogenic movements is obviously not in conformity to the actual situation. Therefore, the geosyncline-platform theory is correct in expounding the process of formation of a platform region and in elucidating the features of some stages in the history of crustal development, and thus it has undeniable historical significance in geotectonics. But the theory has some defects in mirroring the regularity governing crustal development.

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① The terms mobile region and "stable" region are relative. A "stable" region also bears tectonic movements and accompanying magmatic activity with a certain intensity, form and nature. However, they are weak compared with those in a mobile region and have a different form and nature.

3 Platform Activation and the Third Basic Tectonic Element

The fact of platform rejuvenation was first discovered by Soviet geologists, especially by N. I. Nikolaev, G. F. Mirchink, S. S. Shultz, E. V. Pavlovsky, V. V. Beloussov and others. Afterwards, the phenomena of platform rejuvenation were discovered one after another in some parts of the world that had been wrong treated as either geosynclinal or platform regions or had been erroneously regarded as paraplatform or parageosynclinal regions. It is quite evident that platform activation is not a local, accidental phenomenon, but a prominent, widespread, new-'type crustal movement.

Based on the investigation of the geological development of eastern China since Middle Mesozoic time, the author considers that the phenomenon of platform rejuvenation is especially obvious in China. There are different viewpoints in Chinese and foreign geological literature about the tectonic nature of such regions as eastern China. For example, Huang Jiqing[5] names some of this region as platforms and the others as parageosynclines or paraplatforms. But studies by numerous geologists and observations by the author[6,7,8,11,16] suggest that most of the region had been converted by Paleozoic time from a geosynclinal into a platform region, the extensive ancient "Chinese Platform". Except parts of the region where "posthumous activity" due to remaining influence of an ancient geosyncline and "preludial activity" prior to platform activation occurred resulting in large-amplitude up-and-down movements, thick sedimentary cover, tilting or slight folding (expressed by unconformities in the cover), the basic features of most of the region are not much different from those in other platform regions in the world throughout most of the period. Only in the Middle Mesozoic did most of the ancient platform region experience violent tectonism, which clearly went beyond the category of platform-type crustal movements. Therefore, there is no better explanation for such a region as eastern China unless regarded as an example of platform rejuvenation. Recently, a number of Chinese and Soviet geologists, e. g. Yu Deyuan (1954), Zhang Wenyou (1959), U. A. Kosigin and N. P. Heraskov hold the same view about that. Owing to the accumulation of geological data collected by innumerable geologists and the author from investigation on the spot, the phenomenon of platform rejuvenation is further clearly recognized. On the basis of the results of predecessors and the author's on-the-spot investigation, the author has attempted to extend and develop an idea on platform rejuvenation, and systematized it to form a complete theory, "theory of platform activation".

Platform activation named by the author implies that a platform ("stable") region resumes high mobility after a "stable" period, and experiences violent tectonism which clearly goes beyond the category of platform-type crustal movements, and therefore transforms into a new mobile region. As a new-type crustal movement, it may be divided into four types in terms of form of expression[16]. Many Soviet geologists, e. g. N. I. Nikolaev[27] S. S. Schulz[21], E. V. Pavlovsky[2], U. A. Kosigin[24] and V. N. Pavlinov[25], had noticed many areas where platform activation had taken place. Examples

include Donets (Europe) and Wichita (North America) in late Paleozoic time, eastern Africa in Mesozoic-Cenozoic time and Tianshan (Central Asia) in Cenozoic time. Among them, Donets and Wichita are characterized by giant, deep troughs, which can be named as "donets type"; eastern Africa, by intense faulting movement and violent volcanic activity, which can be named as "eastern Africa type"; and Central Asia, by large-amplitude arcogenesis[2], faulting and up-and-down movements to form high uplifts and low valleys, which can be named as "Central Asia type". Besides, there is Cathaysian type which appears typically in eastern China and is also present in southern and eastern Siberia (Baikal and Aldan) and in western North America (Rocky Mountains). It is the most widely distributed of the known four types, and is characterized by widespread small depressions arranged in rows and by violent magmatic activity.

Platform activation can be roughly divided into three periods. As known from examples, it began in late Paleozoic time. In the period from late Paleozoic to early Mesozoic, platform activation took place only locally and belongs mainly to Donets type. Examples are Donets and Wichita. Represented by platform activation of Donets type, this period is termed "Donets age". By the Middle Mesozoic, platform activation had quickly spread all over the world, such as eastern China, eastern and southern Siberia, eastern Africa and western North America, where the main activation occurred just in this period. This period lasted from the Latest Triassic to the Early Tertiary, when platform activation of both Cathaysian type and eastern Africa type appeared, with predominance of the former. Therefore, the period is called "Cathaysian age". During the Cenozoic, platform activation continues on and is still violent today, as in Tianshan and Pamirs of Central Asia. They belong to Central Asia type so that they are called "Central Asia age".

Exemplified by Cathaysian type, the development of platform activation may be roughly described as follows. In the initial-mobility period, owing to arcogenesis or/and faulting, large-amplitude and rapidly subsiding depressions appear on an originally flat platform. These depressions are called "diwa" (geodepressions), while the rises between them are named "geodomes". During the subsidence, diwa-type sediments characterized by a molassoid formation and occassional intercalated volcanic material are deposited. In the gradual advance period① diwa continues to subside, and diwa-type sediments continue to thicken, with accompanying intense structural deformation (folds and faults) and magmatic activity; both diwa-type sediments and the upper and lower structural layers of the original platform are disturbed by them. In the maximum-mobility period, diwa subsidence or relative subsidence reaches the maximum depth and diwa-type sediments also reach the maximum thickness. At the same time, tectonic movement and magmatic activity reach the limit. As a result, diwa-type sediments or the upper and lower structural layers form a "fault-fold belt". In the residual-mobility period, tectonic movement and magmatic activity gradually drop in intensity, but still operate. Simultaneously, "sediments of diwa fault-fold intermontane depressions" appear in the newly formed intermontane depressions. The process of

① The "gradual – advance period" is merged into the "initial-mobility period" in the papers hereafter.

platform activation of other types is probably somewhat different from that of this type. But the nature and intensity of platform activation, regardless of type, indicate that the discussed region is no longer a "stable" platform region, but has been converted into another tectonic region. The "theory of platform activation" states that the trend in crustal development is not simple, straight, only from a mobile to a "stable" region. Just as mobile regions can change into "stable" regions, "stable" regions can also change into new mobile regions. In one word, the relationship between mobile and "stable" regions is dialectical and interchangeable. Certainly, the so-called interchangeable relationship does not mean the simple repetition of a tectonic element, because a newly formed mobile region is not identical with a geosynclinal region (see below). The theory also states that the known basic tectonic elements of the crust are not only two but three. The platform ("stable") region transformed from the geosynclinal (mobile) region is definitely not the final form of crustal development. After the platform region, a new kind of basic tectonic element representing a mobile region has obviously formed. This recently known basic tectonic element is named a "diwa region" by the author[2]. It is the last one of the three basic tectonic elements which have been studied in most detail, and hence it can be named as "the third basic tectonic element". Thus, it can be seen that platform activation and appearance of the third basic tectonic element can not be regarded as exceptional cases occurring only in certain areas. In fact, they represent a natural process and trend of crustal development, just as geosynclinal regions become "stabilized" and change into platform regions. The author has written a special book in proof of the theory of platform activation[16] and thus it is unnecessary to go into details (Fig. 1).

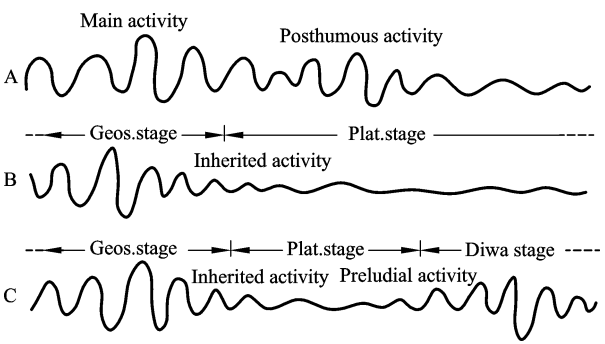


Fig. 1 Comparison of a geosynclinal (A), a platform (B) and a diwa (C) region in terms of the process of geological development. The amplitude of the curves denotes the intensity of activity

The term "diwa region" is a synonym of the term "activated region"—product of platform activation①. In terms of construction, sediments, structures and magmatic activity, this new basic

① When the author recognized this new tectonic region, he also proposed another term, "activated platform", which was accepted by other geologists. Because the term may be easily misunderstood as one kind of platform or being equal to paraplatform, and hence it can not exactly express the fact that the region is a new tectonic element transformed from a platform region and different from it, it is inadvisable to be continuously used. Therefore, a well-defined new term "diwa region" has been introduced.

tectonic element is different in tectonic nature from both geosynclinal and platform regions. Its main properties may be summarized as follows.

Firstly, there are three basic structural layers in construction (Fig. 2C)[14]. Among them, the first layer is made up of geosynclinal-type sediments, which has undergone violent folding, magmatism and metamorphism. The second layer consists of platform-type sediments, which rests unconformably on the former. Obviously, the two structural layers are correspondingly the folded basement and sedimentary cover of an original ancient platform region. As for the "third structural layer", it is a characteristic, new basic structural layer, which differs from both the first and second layers. This structural layer is composed of "sediments of depression type" (also named the "third kind of sediments"), mainly clastic rocks of continental facies characterized by a molassoid formation. "Sediments of depression type" occur on an ancient platform without preparation of a geosyncline. The layer has frequently been influenced by violent magmatic activity, accompanied occasionally by volcanic eruptions. These peculialities show that it differs from other "sediments of depression type" deposited in foredeeps and intermontane depressions, which are characterized by a genuine molasse formation. In fact, it is laid down in diwa formed on an original platform during its activation and characterized by large-amplitude subsidence. Therefore, it is named "diwa sediments", and the "third structural layer" composed of the sediments is named "diwa sedimentary layer"[15]. It is also named "activated structural layer", as the layer is the product of platform activation. The discovery and recognition of the third structural layer is very significant, because the layer is one of the major features of the new tectonic region transformed from a platform region, and is an important criterion for discriminating the new tectonic region transformed from the platform region, (Fig. 2B and C)[14].

Secondly, the new tectonic region formed by platform activation shows more violent tectonic movements than the platform region. Folds formed by platform activation mainly belong to open type, but a few belong to tight type. In addition, there are obvious faults and even overthrusts. The structures not only occur in the third structural layer, but have disturbed the second and even the first layer (Fig. 2C).

Thirdly, in terms of intensity and scale of magmatic activity, the new tectonic region is markedly different from the platform region characterized by weak magmatic activity. But it is similar to the geosynclinal region in voluminous granites and volcanics. These products of magmatic activity may disturb the third layer, and also influence the first and second layers. The major difference in magmatic activity between the new tectonic region and the geosynclinal region is that magmatic activity in the former takes place simultaneously with diwa-type rather than geosynclinal-type sediments (Fig. 2A and C). Furthermore, magmatic activity in the former develops from acid to basic. That is to say, in many cases, acid and intermediate rocks are dominant in the early stage, but basic rocks predominate in the late stage. However, magmatic activity in the latter is opposite to that in terms of order.

Finally, the new tectonic region topographically is characterized mostly by a marked undulation