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# DEVELOPMENTS IN GEOLOGICAL WORK IN COMMUNIST CHINA IN THE PAST DECADE

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It has been ten years since the establishment of the People's Republic of China. Since that time, the Chinese people have gained decisive victories in socialistic revolution and made glorious achievements in socialist construction under the capable leadership of the Chinese Communist Party.

Among China's socialist construction tasks, her geological workers have gloriously shoulder the work of large scale prospecting for different mineral resources and the work of hydro-geology and engineering geology in connection with different hydraulic projects and river planning for the socialist construction of their fatherland. They have also rapidly raised the technical level of China's geological science.

Under the leadership of the Party and the government and with the enthusiastic support of the entire people, and the generous and unselfish assistance of brother nations, especially that of the Soviet Union, many new accomplishments have been made and the original countenance of China in geological work has also been dundamentally changed. The geological work of China has been unprecedentedly developed in a short period of ten years.

The old China prior to liberation was a colonial and semi-colonial country. Because of the decayed policy and the reactionary social system, the geological work at that time was unavoidably limited to a large extent to describing disconnected facts or to the search for useless theories. There was very little work which directly served production.

In fact, it was merely a little bit of an ornament under a reactionary control. Consequently, the foundation which was passed on to new China was extremely weak. Only with the victory of revolution of the Chinese people and the establishment of the People's Republic of China did China's geological work enter a brand new period of history and gain an impressive development.

Following the development of national economy, the geological work of China may generally be divided into three stages since the formation of the People's Republic. The special characteristic of each stage has been a general adherence to the needs of development of socialist national economy. And the most fundamental characteristics of each stage have been the placing of geological work in the orbit of the national construction plan and the thorough practice of the mass line in order to intimately serve socialist construction tasks and to serve in the interest of the working class and the entire labor population.

The first stage was a period of taking over and reorganizing geological organizations of old China, the establishment of a new leading organization, and the building of a new foundation for geological work. It was also a period of rehabilitation of national economy after the working class of China had triumphantly gained political power.

At the initial stage of this period, existing geological organizations in different areas were separately taken over and then gradually reorganized. Under the direction of the Party and the Central People's Government, the Planning and Guidance Committee for Geological Work of China was formed in 1950, and the geological workers of the country were properly centralized and organized to participate in the construction of the fatherland. As a result, the situation of individual actions, indifference, and mutual incrimination which existed in the geological work of the past was forever eliminated.

To meet the development of national construction tasks, the Ministry of Geology under the People's Republic of China was formed in 1952. Large numbers of cadres were gathered and many training classes were set up. Large amounts of equipment were added, and geological bureaus were established in all the large administrative regions.

The organization of a large number of geological prospecting teams was started, the leadership of the Party was vigorously strengthened, and comparatively large scale prospecting work was selectively and rapidly implemented. During this period, colleges and schools of geology were also established, and the large-scale training of a new born geological exploration force began.

In this manner, an unprecedented new state of affairs in geological work was started in the history of China. This established a new foundation for an even greater development in the geological work of China.

Through the care and assistance of the Party and having gone through the training of many social improvements and political movements, the political awakening of many original geological workers was generally improved. They began to understand that in the work of fatherland construction they had to follow the entire people of the country and join the army of geological prospecting in a fighting spirit.

From the standpoint of the geological workers who had long been used to the geological working methods of old China, such a drastic change was an extraordinary matter. For example, some paleontologists, including palaobotanist, were able to leave temporarily on a short notice the identification of their long gathered samples and join the urgently needed geological prospecting for coal fields and underground geological work of mines.

There were mineralogists who left their debates on theories of granitization and magmatic movement and their studies on certain rock forming minerals with indicative characteristics and the transformation process of these minerals, and joined the mountain area work for the prospecting of different metallic minerals. A feeling of uneasiness was difficult to avoid at the beginning.

However, because of education and elucidation by the Party and affected by the ardor of the entire people of the country for socialist construction, their patriotic feeling was highly elevated and they realized the very great significance of working and serving of the people. And they gradually overcame their individual difficulties and, furthermore, made definite contributions.

At the same time, we also received assistance from Soviet specialists and learned their advanced experiences. We were provided with many timely and beneficial advices for our decision on a concrete direction and method in our exploration work. This helpful assistance was very significant at a time when we were creating new organizations for geological work and establishing a new foundation.

The second stage was a period when the geological work of China was traveling further to great developments and great changes on the foundation of the work of the first stage. It was also a period when, under the direction of the Party's general line in a transitional period, China's national economic construction victoriously completed and overfulfilled its first Five-Year Plan.

This was a period when the struggle of the entire people under the direction of the Chinese Communist Party to fulfill the overall task of a transitional period had a decisive significance. In order to fulfill this overall task of the Party in the transitional period, the prime responsibility of geological work was to guarantee the state with urgently needed mineral resources for industrial and agricultural construction. At the same time, the needs of the state in its long range plan of economic construction also had to be taken care of.

Because of the heavy task,urgent requirement,and our small force during the first two years of this period, we concentrated our major strength in ore delineation work of key mining regions where an urgent need for industrial construction existed and in general prospecting in areas surrounding these mining regions. And we carried out large scale exploration for petroleum resources in promising regions.

The Soviet Government sent to us during this period an even greater number of geological specialists of different specializations, including specialists for planning work, diamond drilling, and machinery work, and introduced to us its advanced system of geological exploration work and a series of operating procedures for diamond drilling, mountain area work, taking samples, chemical analysis, etc. Methods of calculating different grades of reserves were specified, and new techniques of all aspects of geophysical prospecting were introduced to us. As a result, the efficiency of our geological work was greatly improved.

In order to satisfy the needs of our work in its continued forward development, we transferred a considerable number of geological workers to be engaged in the training of new personnel. Beside strengthening and expanding higher geological colleges and schools and middle grade technical schools of geology, we also improved teaching methods, and in this field we also received some very big help from the Soviet specialists.

Aside from completing and overfulfilling the task of determining reserves in our geological exploration work, the nature of a number of deposits was also determined, thereby gaining geologically some new understanding. In iron ores, the widely distributed An-shan type of iron ore consists of banded magnetite and hematite that occur in the pre-Sinian metamorphic series, similar to the "iron-bearing quartzite" of the Soviet Union and the taconite of the United States.

However, this type of iron deposit in China is usually more highly metamorphosed, and locally has been subjected to varying degrees of granitization. It contains either a rich primary ore or a high grade ore concentrated by hydrothermal solution.

Hypothermal and pneumatolytic metasomatic-magnetitie and -hematite depositis were discovered in the western part of Inner Mongolia. This was a new type of deposit discovered for the first time in China. It lies in pre-Sinian dolomite and is genetically related to the slightly alkalic granite in the nearby area. Clear and widespread metasomatic replacement of alkali metals and certain other elements are found in the country rock of the iron ore. During the prospecting work in this mining region, very large reserves of certain other elements were also obtained, in addition to the dlineation of reserves of iron ore.

In the Liaoning and Inner Mongolia regions, both types of iron deposits described above are located in and obviously controlled by the east-west structural belt of Yin Shan [mountain].

Regarding the copper ores, we first determined the nature of the Tung-ch'uan type of bedded copper ore and the Ch'i-lien Shan region pyrite type of copper ore. The former is a simple copper ore deposit that lies principally in pre-Sinian dolomitic limestone. It is related to the local gabbro and is controlled by the north-south structural belt. The latter lies in metamorphosed medium-acidic volcanic rocks, especially in fine green keratophyres. It is also a deposit with a very important industrial value.

Next, we identified the Chung-t'iao Shan type of Micro-fissure-filling copper deposit. It lies in pre-Sinian metamorphosed grano diorite and granite porphyry. The deposit is very large and is probably the oldest among similar deposits in the world. The skarn type of copper ore of T'ung-kuan Shan in the middle Yangtze River lies in a contact zone of diorite and limestone. It is controlled by the Cathasian structural system, namely the northeast striking fold belt, and this type of deposit is one that is widely distributed and comparatively important in China.

The understanding of the nature and formation of the above types of deposits provides an important lead to future exploration and delineation of similar types of iron and copper ores.

The continued rapid development of the state's industrial construction requires us to carry out general survey and further prospecting work on the basis of known geological conditions. The most important geological condition is the known distribution of most of the important mineralized regions in a number of areas.

Which of these areas concide with the major or first order structural belts? In other words, the distribution of known mineralized regions are controlled by some of the major structural belts. Some of the ore bodies and ore veins are controlled by second order and third order structures produced by the tectonic movements of first order structures.

Some of the structural belts are isolated. Some interesect other structural belts and a concentration of mineralized areas is often found in these areas of intersection.

Large ore regions controlled by first order structural systems may be divided into the following five different areas:

1. The uplifts, depressions, and folded areas surrounding the Tibetan plateau andthe neighbouring areas. This covers the Chinese part of the T'ien Shan folded belt, the Kun-lun Shan folded belt, the Ch'i-lien Shan folded belt, the north-south striking folded belt of Tsinghai, Szechwan, and Yunnan and the intermount basins such as the Dzungar, Tarim, and Tsaidam basins. Signs of different period and different types of igneous rock activities and structural belts formed by many movements are found in these mountain fold regions. Various types of metallic deposits are principally looked for in these structural belts. Petroleum and useful salts are looked for in the large and small intermount basins of this area, in other words, in the strata of lacustrine or lake-sea facies.

Copper, lead, zinc, and iron are the principal deposits in the Chinese part of the T'ien Shan folded belt. Tungsten ore as well as deposits of rare elements related to pegmatic granite are also found.

Iron ore and non-ferrous ores have been discovered in the Kun-lun Shan folded regions, which have various industrial values. This gigantic folded area is actually connected with the east-west structural complex of Ch'in Ling. However, having been pushed by the Tibetan massif, its position is slightly to the north.

In the old folded belt of Ch'i-lien Shan, slightly metamorphosed, banded iron ore which contains jaspilite and possibly belonging to marine deposits of the Cambro-Ordovician period has been found. This is a newly discovered form of deposit. It is very large, with very big reserves. The principal ore-bearing rock is phyllite with quartzite, interbedded with intermediate volcanic rocks. The ore bed is compactly folded extending in the northwest and southeast directions, and it is controlled by the first order structure of the Ch'i-lien Shan fold. Very large reserves of lead and zinc ores have also been found, which are in a deposit of pre-Sinian metamorphic rock. The country rock of the deposit is consisted of marble and green schist. The ore bodies occurs in bands or lenses with ore pockets and ore shoots in localized areas. Beside following the changes of rocks, the ore bodies and ore veins are also controlled by fissures in second order vortex type structures.

Pyrite type of copper ore, complex metal ore, a number of chromium ores, platinum ore, copper-nickel ore, pre-Sinian gold ore, and native copper in metamorphic rocks are also found in the Ch'i-lien Shan folded belt.

A north-south first order intensely folded belt appeared in the western part of China at least as early as the Mesozoic era. This structural belt coincides in both character and in position with the north-south linear structural trend as pointed out by academician K'a-erh-pin-ssu-chi, an outstanding and elderly geologist of the Soviet Union.

Many minerals have been found and prospected in the north-south trending folded belt. These include cassiterite, the skarn type tin ore; sedimentary iron ores of upper Paleozoic epoch, copper ores of Permian, Triassic, and Cretaceous ages, different types of lead and zinc ores, Tung-ch'uan type of copper ore, mercury ores of Western Yunnan area, etc.

The distribution of these mineralized regions is clearly controlled by the north-south first order folds of this large region and the closely related northeast-southwest or northwest-southeast striking torsional fractures. A few examples from south to north are given below:

This north-south structural belt is one of China's important tin ore producing areas, such as the tin mines in the Ko-chiu area where the tin ores lie in contact zones between carbonate rocks and intrusive granite, granite porphyry or quartz porphyry. Cassiterite, the sulfide-bearing tin deposit, is particularly well developed. Talus and residual types of placer tin related to this type of deposit are also of very large scale.

In Hui-li area of Szechwan and Yung-ch'uan area of Yunnan, small basic and ultra-basic stocks are fairly abundant, and most of them show signs of copper and nickel mineralization. This entire mineralized belt lies close to the north-south direction.

The magnetite deposit of P'an-chih-hua and the copper-nickel ores in areas to the east are also in this north-south structural belt. The former lies principally near the base of gabbro; the ore body seems to be in beds, the distribution of which is controlled by northeast direction fractures. The latter extend along north-south direction in pre-Sinian metamorphic rocks and is intruded by diorite, gabbro, pyroxenite, and dunite. The ore bodies lie principally in the basal part of the [intrusives] and in the dunite and pyroxenite in the country rock. Besides extending along the north-south direction, the ore bodies are also controlled by secondary fractures in other directions.

The deposits in the large basins surrounding the Tibetan plateau are mostly of continental facies. General exploration and evaluation of petroleum have been carried out in these areas during the past few years. The earliest work was done in the Dzungar basin of Sinkiang. At first, a wider scale exploration was done jointly by China and the Soviet Union, but concentrated exploration was done by China later in the northern section of the basin.

The Tsaidam basin was originally a barren desert region without any signs of human population, and communication and supply situation was extremely bad. Through the vigorous support of the Party, we entered this basin in 1954 to begin the work of petroleum exploration. Even with the greatest effort, the working personnel was able to travel at most 12 kilometers a day during the initial period. Through this actual exploration and survey work, not only have future petroleum prospects in the Dzungar and Tsaidam basins been determined, but it has also pointed out to us that the general exploration and evaluation for petroleum and other useful salts in other large basins should also be considered.

In addition to petroleum, potassium and boron deposits precipitated in the salt lakes of these basins have also been discovered, and they also contain such elements as bromine, iodine, and lithium.

Potential reserves of both potassium and boron are very extensive. This discovery will change the past concept that inland salt lakes are not rich in potassium salts, and has provided a new direction for the search of deposits of potassium salts.

2. The NNE-SSW swells, depressions, and folds of the coastal region of eastern China. This structural belt has always been called the Neocathasian structural system. Academician Ssu-mi-erh-no-fu once strongly and accurately stated the importance of the Pacific metallogenic belt, and the above structural belt is part of this Pacific belt. Its importance has been completely proven by results of prospecting and general survey work in a number of related regions in China. Moreover, a number of non-metallic deposits has also been discovered.

The inland part of this structural belt covers the mountain regions from Ta-hsing-an Ling [Great Khingan] in the north, to T'ai-hang Shan and Lu-liang Shan, the eastern section of Ch'in Ling, and western Hupeh, to the border of Hunan and Kweichow. Areas of depression in the western part are divided by Ch'in Ling into two basins, namely, the northern Shensi basin and the Szechwan basin.

In its eastern part is an even larger area of deposition and subsidence which is underlain by the Sung-liao plain, the bay of Po Hai, the North China plain, and the Heng-yang basin. Further east are belts of smaller uplifts and depressions, which are parallel to each other. The folds seem to become more and more pronounced towards the ocean, and signs of igneous rock activities are also more intense and more numerous.

Within this wide structural belt of the first order of magnetite,on the basis of the characteristics of the mineral deposits of the various belts from inland to the coast, deposits of industrial value have already been discovered in many regions.

A. In addition to prospecting in a number of regions on the rich reserves of Jurassic and upper Paleozoic coal, a great deal of exploration work has also been done on petroleum and on deposits of different types of salt in the northern Shensi basin and the Szechwan basin which lie west of the inland elevations of the Pacific metallogenic belt. Results of geological work in recent years have proven that the Szechwan basin is, particularly, a potential region of petroleum reserves.

B. Within the area of uplifts and folds of the Pacific metallogenic belt, namely the area from Ta-hsing-an Ling [Great Khingan] to the mountains on the border of Hunan and Kweichow, the principal mineral products include the porphyry copper of the Ta-hsing-an Ling region, Ta-miao type vanadium and titanium-bearing magnetities, Sinian sedimentary iron ore, Chung-t'iao Shan type of micro-fissure-filling copper ore, sharn type of lead and zinc ores of Hunan and Kwangsi, Hsi-k'uang Shan type of antimony ore of Hunan, mercury ore of western Hunan and eastern Kweichow, etc.

The distribution of these mineral regions is mostly controlled by large NNE-SSW first order "torsional" folds and its closely related NNW-ENE torsional fractures and the WNE tensional fractures. The lead and zinc in Hunan areas and the long famous antimony of Hunan's Hsi-k'uang Shan are clear examples. The area between Hunan and Kweichow is one of China's important regions of mercury distribution. Mercury ore had had a long but scattered history of development, but systematic prospecting has only been carried out since liberation. Mercury ores are found in different types of rock formation of Cambrian to Triassic ages. Deposits are of the bedded or fissures-filling type or a combination of the two. The entire mercury ore belt extends to the north-northeast or close to north-northeast direction and occurences are found along the axial part of anticlines or in fractures along the same direction. However, many ore veins are found as fillings of tensional fractures running in the northwest-west direction which are related to folds with axes in the north-northeast direction.

There are also many ore bodies and ore veins which are controlled by a secondary structural system or affected by a different structural system. [not clear whether refer to mercury or other minerals] Within the territory of Shansi of this inland area of the Pacific metallogenic, there are some well-known areas of alkali rock.

C. Petroleum exploration and general survey work is now being carried out in the Sung-liao plain, the bay of Po Hai and the North China plain, and diamond drilling is now being carried out in the Sung-liao plain with the discovery of many oil-bearing sand. This type of discovery is a very great encouragement to the petroleum exploration and survey work in other areas, such as the bay of Po Hai, the North China Plain and the Northern Kiangsu Plain, since these regions, from the standpoint of geologic structural system, belong to the same type of regions as the Sung-liao Plain. Furthermore, signs of oil gas seepage and floating asphalt have already been discovered in these regions.

D. The southeastern mountain and hill area of the Northeast Region. This covers the north-northeast and northeast folded belt from Chang-kuang-ts'ai Ling to Liao-tung peninsula. Skarn type of lead and zinc ores have been found in this area. They are related to the small, intermediate intrusives in their neighbouring areas and are hypothermal and mesothermal metasomatic deposits. The lead and zinc ores in both the eastern part and northern part of Liaoning belong to this type.

The former lies in the contact region between the above north-northeast structural belt and the east-west structure of Yin Shan; the ore bodies extend in the east-west direction. The latter lies in dolomitic lime-stone of Sinian or pre-Sinian age and is also located in the contact region of the above two series of structural belts. Its ore bodies are very large and lie close to the east-west direction. The lead and zinc ore are of high grade and is one of China's large lead and zinc deposits.

A very large reserve of micro-fissure-filling type of molybdenum ore has been discovered in Kirin, which lies in small intrusive and brecciated country rock. The ore belt extends along the north-northeast direction of the first order structural belt.

However, the ore bodies and ore veins are controlled by tensional fractures close to the east-west direction, which are related to a compression belt striking north-northeast. As a result of the discovery of the micro-fissure-filling type of molybdenum ore in Kirin and other regions, China's reserves of molybdenum ores have jumped to a front ranking position in the world.

The simple molybdenum ore of the skarn type discovered in Liaoning Province is a type of ore which has seldom been seen in the past. It has already been ascertained that it possesses a very important industrial value. The magnesite of Liaoning is also in this structural belt, and it lies in dolomite and limestone of Sinian age. Other useful elements have also been discovered.

E. The southeast coastal area. This is an area with an extensive exposure of metamorphic rocks, a lot of granite intrusions, and a wide distribution of extrusive rocks, especially andesite. It belongs to the Cathasian system and it is especially a part of section of the Neo Cathasian system. The principal minerals of this area is the micro-fissure-filling type of cooper ore in eastern Kiangsi with its associated lead and zinc ores. The ore bodies lie mainly in contact zones of granite-diorite porphyries and metamorphosed volcanic rocks. Similar ore bodies are also found in Chekiang.

Very extensive alunite deposits are found in Fukien, Chekiang, and Anhwei. These are hydrothermal metasomatic deposits. They lie in volcanic tuff and tuff breccia, and occur in beds and in lenticular shape. A number of skarn type of iron ore deposits are found on the Hainan Island and the coastal areas of Fukien and Chekiang, and these also have important industrial values. Within the territory of Kwangtung Province are also found skarn type of lead and zinc ores. The distribution of all the deposits described in this section are controlled mainly by the Neo cathasian structural system.

3. Yin Shan area. This is an area which crosses from east to west, starting from Ch'ang-pai Shan in its eastern section and going west through the northern part of Hopeh, the Inner Mongolia Autonomous Region, and the borders of China and Mongolia, and all the way to Sinkiang. The geology of this area is quite varied.

There are intense folds of old metamorphic rocks, which strike in the east-west direction. Affected by other components of the Neo cathasian structural system, namely, the above mentioned north-northeast striking uplifts, fold, and depression belts, a east-west striking fold belt shows up on the surface intermittently in its eastern section.

It is because of this type of superposition and interference that there are comparatively large numbers of polymetallic mineralized regions, among which are vanadium and titanium-bearing magnetite ores and lead and zinc ores. Its middle section covers the Yin Shan range and the area west of the northern part of Lang Shan.

The strike of the fold axis is in the east-west direction, and the area is composed principally of close folds of metamorphosed rocks. Volcanic rock and intrusives are also found in some places, which form low lying mountains in semi-desert areas. Except for minor local changes, the geology of its western section is generally the same as its middle section.

Aside from the above mentioned vanadium and titanium-bearing magnetite, and lead and zinc deposits, other major deposits in the eastern section of the Yin Shan area include metamorphosed, sedimentary, An-shan type of iron ore of pre-Sinian age and coal of upper Paleozoic epoch. Iron ore, rare earth elements, rare elements, and coal are found principally in its middle section, and recoverable non-ferrous mental deposits, such as lead and zinc, and copper, have been found in its western section.

4. Ch'in Ling area. Prospecting work in this area during the past few years has been concentrated in the middle and eastern sections, namely, the area from Lan-t'ien of Shensi to I-yang of Honan. Beside iron ores of skarn type, and copper, lead, and zinc ores, another major mineral product found in the middle section of Ch'in Ling is the very large micro-fissure-filling molybdenum deposit in Shensi in the northern middle part of the section.

The molybdenum ore bodies lie mainly in metamorphosed andesite of Sinian age, and secondly in the porphyritic granite which is closely related to the ore formation. South of the mineralized region lies a gigantic fault running in the east-west direction, and the ore bodies are controlled by northwest running torsional fractures which are related to an east-west striking compression belt. The intrusives of porphyritic granite extend in the same direction as the ore bodies.

In the slightly eastern part of the middle section of Ch'in Ling iron ores of industrial value have been found in pre-Sinian period formations. In the part of eastern Ch'in Ling which extends towards the coast, namely the Hai-chow area, apatite deposits have been surveyed, which lie in crystalline schist and magnatite. This ancient rock system forms a tight fold with axis in the east-west direction.

5. Nan Ling area. This is also a complicated east-west structural belt. However, its surface structures are not nearly as outstanding as the Ch'in Ling and Yin Shan areas, although many protruding granite bodies are seen in this area. The arrangement of these bodies and the direction of extension of individual intrusive bodies as well as the strikes of ancient rock folds are often close to the east-west direction. Many areas in this east-west structural belt were often the subjects of disturbances by other structural systems, especially the new Neo cathasian system. This type of disturbances had a definite significance to the distribution and the way the deposits are found.

Comparatively extensive prospecting and general exploration for different types of metallic minerals have been carried out since liberation in this Nan Ling area which covers southern Kiangsi, southern Hunan, northern Kwangtung, and southeastern Kwangsi areas, especially for those of tungsten, tin, and their associated non-ferrous metals. The tungsten ores in this region are principally the wolframite-bearing quartze vein type and the skarn type scheelite deposits. The former is found in siliceous and aluminous rocks, while the latter is found principally in carbonate rocks.

Judging by geological data obtain through actual prospecting the overall distribution of tungsten, tin, and other metallic ores in the Nan Ling area is close to the east-west direction and is in the shape of a belt. Beside rock folds and igneous intrusions running in the east-west or close to the east-west direction, such folds and intrusions are also found in the north-northeast and north-northwest directions in this east-west structural belt. However, it should be pointed out that in the Nan Ling area the first order structural control of the mineralized regions lies with structural systems close to the east-west direction.

In conjunction with the general exploration work, we have also carried out in the above described areas the work of areal geological survey and mapping of 1:200,000 scale, such as the Ta-hsing-an Ling [Great Khingan], Ch'in Ling [Tsing Ling] Nan Ling, and Sinkiang regions. In this areal survey work, we also received the entusiastic assistance of a large number of young geological workers from the Soviet Union.

Varying amounts of rare and dispersed elements were discovered in the above five areas, especially in the three complicated, east-west structural belts. Consequently, many deposits of considerable importance have already been found even though the work of searching for minerals in these areas has been carried only for a short time. This indicates a fine future ahead.

From the standpoint of characteristics of magmas, our work of geological prospecting and general exploration during the last few years points out that large quantities of chromite exist in ultra-basic type of dunite and serpentinite. In regions where gabbro, serpentinite, and gabbroid basic rocks are developed, nickel sulfide ores and silicate nickel ores of considerable scale and vanadium and titanium-bearing magnetites of very large scale are found.

Based on results of preliminary analysis of data obtained in China on relationship between acid magma and mineralization, it may be said, as far as a number of principal ore minerals are concerned, that tin is mostly related to alaskite, tungsten is mostly related to biotite granite, molybdenum mostly to adamellite and biotite granite, and iron mostly to quartz-diorite. Deposits of rare earth and rare elements have also been found in a number of alkalic rocks.

Summarizing our work during the second stage, we could list the following characteristics: our forces became stronger than ever and the types of workers became more complete. Ore reserves were also greatly increased. With the help from specialists of the Soviet Union and other fraternal countries, we also extensively promoted the use of new techniques. In geological exploration work, we extensively utilized techniques of geophysical and geochemical prospecting and aerial topographical survey in connection with areal geological work. This was in addition to a great deal of diamond drilling work and light and heavy types of mountain area work.

In our diamond drillijg work, we did some deep well drilling in petroleum exploration. Definite difficulties were encountered at the beginning of this work. However, after intensifying our studies on the advanced experiences of brother countries, we were able to gradually overcome these difficulties.

We utilized many geophysical prospecting techniques to effectively coordinate with our geological work. In ferrous metals, noted results were made in detecting hidden deposits. For instance, in connection with chromium ores, we used aerial magnetic survey to delineate the distribution of few thousand square kilometers of ultra-basic rocks in the barren, semi-desert regions of Inner Mongolia, which gave us a range in which to look for chromium ores.

In different metallic ores, we also effectively expanded the range and prospect of some mineralized regions while carrying out prospecting work in production areas. For instance, along the boundary of Ch'i-lien Shan, a very large unexposed ore body of lead and zinc was detected by the electrical method.

In connection with the general exploration work for minerals, some structural belts related to mineralization were found. For instance, an east-west structural belt as mentioned above, seemed to exist along the An-shan area of the Northeast as indicated by its appearance and disappearance from section to section and the existence of this east-west structural belt was definitely proven through geophysical prospecting, and this belt is found to be actually the eastern extension of the east-west belt of Yin Shan.

To coordinate with the work of general exploration for petroleum, data relating to geodetic structures, especially on basement of plains, were provided for such areas as the Tsaidam [Basin], O-erh-to-ssu, the Sung-liao Plain, North China Plain, and the lower and middle reaches of Yangtze River. In order to serve to explain the geological structures of some regions where petroleum exploration was carried out, a lot of key data were also provided. This had an important significance to the planning of petroleum exploration work.

Geochemical prospecting has also been one of the new techniques employed. In order that the work of locating hidden ore bodies might be better carried out. The study of primary halos and geobotanical studies have been carried out during the past few years and minute traces of mineralization have been discovered. For example, in the region of copper deposits along Ch'i-lien Shan, where the foliation was well-developed, massive ores occur at depths of more than 150 meters where the surficial rocks show clear primary halos. Some work was done by determining the mercury content of massive rock in addition to studies of the lithology, and the characteristic structural conditions.

We have also carried out aerial survey work over larger regions. Ground survey work particularly in such barren and extremely thinly populated regions as the Tsaidam Basin, Ch'i-lien Shan, Ta-hsing-an Ling and Ch'in Ling would generally be very difficult. The use of aerial photography is not only a rapid process, but aerial survey maps also provide a great deal of convenience in explaining the relationship and structures of rock strata required in geological mapping work.

Large scale river basin planning work and the work of engineering geology and hydrogeology on many large mining and industrial construction bases and in connection with civilian water requirements in cities and towns were also carried out during this period. For instance, in connection with the overall project of eliminating the floods of Yellow River from its roots and its comprehensive development and utilization, the dam site exploration work for the tremendous San-men Gorge reservoir project has already been completed.

Large scale geological exploration work for the selection of dam sites is being carried out along a number of sections of the Three Gorges regions in connection with the tremendously large scale hydroelectric station which will straddle the Yangtze River.

Geological survey work was widely carried out for large and small reservoirs and canal projects which are now under construction in connection with a great effort to eliminate floods and the development and utilization of rivers. These projects are under the river basin plannings of Hei-lung Chiang and Sung-hua Chiang and the Sung-liao Canal in the Northeast, and they are also in connection with Han Shui and other tributaries of the Yangtze River, the Huai River system, Ch'ien-t'ang Chiang and Hsin-an Chiang in the eastern part of China, and the Chu Chiang basin in South China.

A great deal of hydrogeological survey work has also been carried out in connection with large mining and industrial construction, selection and survey of foundations for large bridges, selection and survey of railway routes, water supply of key cities, farmland irrigation, water requirements of cattles, and mineral water for therapeutic purposes; necessary data and resources have been supplied.

In the application of the above mentioned new techniques of diamond drilling, geophysical prospecting geochemical propsecting, and aerial survey, in hydrogeology and engineering geology work, and in the chemical analysis and technical processing experiments of mineral specimens, not only has the Soviet Union sent us many specialists in each field, with some of them actually joining the field teams in their work, thus providing us with tremendous technical assistance, but other brother countries have also sent specialists and rendered us very great technical assistance, such as Rumania in diamond drilling exploration work, Hungary in geophysical prospecting, and Poland in hydrogeology and engineering geology.

Soviet specialists helped us in many different ways. Aside from large groups of specialists who stayed for definite periods of time, went through both good and bad times with us, and cooperated with us both in the office and in the field, there were also others who visited China for only a short time and wrote for us many reports of important academic and practical values. There were even larger numbers of specialists who were not able to visit China, but because of their enthusiastic concern over our work also provided us with valuable assistance through every possible means, including correspondence and the exchange of information, etc.

What was particularly exilarating and made us specially grateful was the constant and deep concern over our work by Comrade Minister Antropon of the Soviet Ministry of Geology and Mineral Conservation. During his two visits to China he earnestly made many extremely important suggestions in connection with the implementation and development of our geological work.

He also negotiated with us on very friendly basis and signed agreements for overall mutual cooperation to solve many mutual geological problems concerning China and the Soviet Union. While they were practical problems, they were also important problems of a general nature in geology.

China's geological work has already entered its third stage of development. This stage corresponds with the initial period of the second Five Year Plan which came after the successful completion and on the foundation of the first Five Year Plan. It is also a time when the Party has achieved decisive victories in socialist Rectification Movement, and on the political and ideological fronts.

Under the beacon of the Party's general line for socialist construction, the people of the entire country are building up their efforts, struggling for the upper reaches, and carrying out socialist construction with quantity, speed, quality, and frugality. During this period, a state of big leap forward has emerged all over the country in political, economic, cultural and educational work and in scientific techniques. This is also the stage of overall and intensive development of China's geological work.

In thoroughly carrying out this entire set of "walking on two legs" policies of the Party, our geological work has started with a greater scale, greater speed, greater care and accuracy, and greater economy.

During the glorious year of 1958, the policy of geological development by the entire Party and the entire people was thoroughly carried out in our geological work.

A mass movement to look for minerals was started on a nation-wide basis, and the size of the movement was unparalleled in history. Many mineral producing areas were discovered, which were worth further exploration. At the same time, the knowledge of geological science and geological exploration was propagated among the large popular masses.

With the maturing of a new born force, the expansion of our organization on a nation-wide basis became possible. Under the dual leadership of the Ministry of Geology and the local governments, a bureau of geology was established by each province, shih, and autonomous region. Furthermore, a decentralization of administrative power was put into practice by the Ministry of Geology, and the power of the bureau of geology of each province, shih, and autonomous region was expanded.

Each bureau became responsible for the work of general survey and exploration of areas under its own control as well as other geological work both inside the office and in the field. Having put into practice the decentralization of administrative power, the principal tasks of the Ministry of Geology became the setting of policies, long range planning of resources and the balancing of plans for the fiscal year, the strengthening of technical direction and the supervision of examinations, and organizing for the exchange of experiences. At the same time, geological organizations of different production departments of the central government were also reorganized.

In order to coordinate with the large scale exploration work, we have also during the past few years gradually strengthened our work of research both indoors and in the field, and attention has been given to the study of certain theoretical problems. It was exactly to meet the requirements of all this research work that many research organizations under different departments of the central government were either expanded or newly established during the latter part of the first Five Year Plan period.

These research organization are geological research institutes under Academia Sinica, which include the Institute of geology and Palaontology, the Institute of vertebrate Palaontology, the Geological Research Institute of Ch'ang-ch'un, and the Geological Research Office of

Lanchow; geological research institutes under the Ministry of Geology which are the Research Institute of Mineral Raw Materials, the Research Office of Geological Mechanics, the Research Institute of Geophysical Prospecting, the Research Institute of Prospecting Techniques, and the Research Institute of Hydrogeology and Engineering Geology; the Geological Research Institute of the Ministry of Metallurgical Industry; the Research Institute of Coal Geology of the Ministry of Coal Industry; the Research Institute of Petroleum Geology of the Ministry of Petroleum Industry; etc. Other geological research organizations were established by local governments.

During the past few years, various high level colleges and departments of geology have thoroughly carried the state's policy of "uniting education with labor production" and have organized large numbers of students, especially those of higher grades, to take part in some of the geological general survey and exploration work.

In this manner, the students have been able to come into contact with production reality while they were still going through school and acquired definite experiences in actual geological work. Moreover, they have also been of definite help to the development of existing geological work.

Because of the large numbers of geological organizations and the wide range of geological work, a geology and mineral products unit was formed under the direction of the National Committee on Scientific Techniques. The responsibility of this committee covers the planning, coordination, and direction of the state's research work on geological science and technqiues in order to avoid duplication of geological research work. Experiences have shown that this organization has been of important significance in the proper work division and cooperation between the different departments engaged in geological research work.

In summarizing our experience in the past, we may say that our organizational work has gradually expanded, leadership is gradually being strengthened, and new born forces are also gradually becoming stronger. We are gradually going deeper into the learning of Soviet's advanced experiences, and the great cooperation between the geological organizations of different areas has also entered into a new stage. We may say that our geological exploration forces can now welcome the new exploration tasks of the state.

Moreover, through a decade of actual work, a lot of data have already been accumulated. From these data, we have acquired a more accurate understanding of certain general and theoretical problems concerning the geology of China. Most of these problems are of key importance. Not only must these problems be solved for the sake of development of research in scientific theories, but their solution will also have an extremely important bearing on the progress of future work of prospecting for resources.

Some of the problems have existed for a long time, and only through exhaustive analysis and further utilization of modern techniques can we hope to solve them. There are other problems of which our understanding is still not sufficiently clear, and we must gather more facts, process them and analyze them before we can accurately present these problems and find the nuclei of these problems.

Regarding certain other problems, we can already find among data presently under our command decisive factors for their solution. From these problems, we now select a few important examples and briefly describe them as follows:

1. The problem of identifying the absolute age of rock strata. With regard to our work in this field, some specimens have already been identified in connection with projects of Sino-Soviet cooperation, and the ages of metamorphic rocks in An-shan and other areas have already been determined through glauconite.

In the determination of geological ages through the radiation method, the values so far obtained are still not reliable enough. This is because the rocks and minerals concerned, having been through a long period of geological action, can not normally satisfy the necessary requirements. For example, the radiation elements in a mineral as well as all substances evolved from them which are vital to age identification must be completely preserved during the entire time of existence of the mineral.

The application of every method of identifying absolute ages also has its individual limitations. We are still in the process of trying to find out which method is more reliable and under what conditions. Consequently, to use the value obtained by absolute age identification method in setting the time of structural movement and its corresponding rock bed still presents some problems.

2. Problem of Sinian period strata. Above the base on which China's ancient rock series were formed and definitely below strata of lower Cambrian age, there exists a rock series which is very thick, and either slightly metamorphosed or not metamorphosed. Except for a number of types of algae fossils, no other fossils have been found. This is what is generally referred to in China as the Sinian system. There are generally two groups of thinking with regard to this problem.

Some people feel that, since fossils of lower Cambrian age been discovered in areas previously considered to be strata of Sinian age and, furthermore, the contacts between strata of Sinian age and Cambrian age are mostly in conformity, all these strata may be included in the Cambrian system, and they have raised the question whether Sinian period actually existed.

Others feel that since in some places, such as the Wu-t'ai area in North China, some of the metamorphosed rocks are considered as metamorphosed glacial deposits and are equivalent to Sinian glacial deposits they should be treated as metamorphosed sections of Sinian age [rocks or] and, therefore, suggest that they be classified under the Sinian system.

Very recently, a rather clear unconformity, although at a small angle, between Sinian and Cambrian age [rocks] was found in Honan. The unconformity between Sinian age [rocks] and the ancient metamorphic rock strata below is even clearer. Consequently, most people are convinced of the existence of Sinian period.

3. The debate on the age of "Devonian strata" in China. Fish fossils which could be classified as ganoid type have been found in the quartz-sand strata that have been classified as belonging to the upper Carboniferous period on the basis of the lepidodendron and other plant fossils. Some people feel that the strata at the most can

not be younger than upper Devonian age, and it is very possible that they belong to middle Devonian period. Recently, others have ventured different ideas. They suspect that the fish fossils may have an extended range. Based on strata of other areas which correspond to the quartz-sand and the fossil group included in them, it is felt that this quartz-sand rock system contains fauna from upper Devonian to lower Carboniferous ages. Consequently, its age should also lie between upper Devonian and lower Carboniferous periods, and they do not agree on its being Devonian period.

4. The problem of division of the boundary of Triassic and Jurassic periods. In the past these had always been thought to be land facies beds and were difficult to divide. Those beds which had been considered as of Jurassic age on the basis of the plant fossils were later thought to be of upper Triassic age. In the last few years, marine facies beds containing ammonite and arietites Waagen fossils have been found in Nan Ling and other areas, which are closely in contact with Jurassic or "jui-t'i-k'o" (or upper part of Triassic period) coal series. This discovery is of a new and important significance to the history of development of China's marine facies beds.

However, the question of how to divide the Jurassic and Triassic periods has never been determined even up to now. Fossil dinosaurs were once found in the "red beds" of Lu-feng area in Yunnan, and the beds were classified as upper Triassic age. The "I-p'ing-lang" coal series below have also been classified under the upper Triassic period. However, in the case of the coal series in Yunnan's neighbouring province of Szechwan which contain plant fossils similar to those of "I-p'ing-lang," dinosaurs have not been discovered even though "red beds" are found above them; these coal series have, consequently, been classified under lower Jurassic period.

There is often a discrepancy between the age of a bed determined by its zoogenic fossils and that determined by its plant fossils. Take, for instance, the red beds in the Hunan-Kwangtung area; those in the Heng-yang area are classified as under the Tertiary period on the basis of the vertebrate fossils. However, through identification of spores and pollen, the coresponding red beds in the P'ing-shih area are classified under Cretaceous period.

Like everywhere else in the world, the problem of division of the Tertiary and the Quaternary periods has long been a subject of debate and without solution in China.

5. Since the ages of rock strata can not be determined, most of the relationship of contacts is not clear either. To base upon individual localized phenomena alone is not sufficient. Consequently, a great deal of difficulty is experienced in identifying the ages of earth crust movements. These problems are now generally handled by directly applying in China the few large movement periods of Europe, not always necessarily supported by a reliable proof of contact relationship of rock beds. Consequently, certain ages as considered by some as periods of large mountain formations are not really determined with accuracy, but are merely hypothetical.

6. Since the ages of earth crust movements of certain areas can not be determined, final decision is also very difficult in positively dating igneous activities and the ages of formation of endogenic deposits which followed these igneous movements, in other words the problem of determining the time distribution of these deposits.

7. Since the ages of geotectonic movements can not be accurately determined, and the thicknesses of rock beds and changes in rock phases are not clear, only a very rough estimate can be given for the line of isopachs of rock beds which have been preserved from different ages. On this basis, the appraisal of ancient geography or structural beds is often not only without real meaning but also may lead to confusion.

8. Problems in geology of Quaternary period.

(1) The question of causes of loess formation. This has also been an old problem. In the past, people thought that all loess had been caused by wind. Through exploration and surveys in the past few years, not only more than one layers of conglomerates have been discovered in the loess in many places but the characterisrics of the loess itself are not completely those of wind formation. Regarding our work of analysis on loess, we still do not have enough data to make our final conclusion. However, the general indication is that its formation was caused by many factors.

(2) The problem of Quaternary glaciation. As a result of the special climatic conditions, the topographical features of most of the mountain valley areas were subjected to intensive destruction during the Quaternary period, especially during the early part of the period. However, in high mountain regions, such sharp remnant features as cirques, U-shaped valleys, hanging valleys (because of the concentration of impact action of flowing water, destruction on the bottoms of these two types of valleys was particularly severe), "Ping-tour" [literally, ice buckets], "p'an-ku" [some kind of valley] as well as "heng-k'an" with wind openings have been preserved. However, some people contend that these features were not the result of mountain valley glaciation.

In locations 10 some to few tens kilometers from above described topography, such as the northeast foothills of Lu Shan, near Ko-ma-shih on the shore of P'o-yang Lake, southeast of Hsiao-lung-t'an on the northeast foothills of Ch'i-yueh Shan at the border of Szechwan and Hupeh, west of En-shih basin, from T'o-k'ou to Ch'ien-yang in the western part of Hunan, etc., very large boulders are found, some times as much as one meter in their long axes. Having crossed plains and hillocks for distances from 10 some to few tens kilometers, these boulders are scattered without any order of stratification in clay conglomerates formed from a mixture of large and small gravels and strongly adhesive yellow clay.

In some special areas, very deep and nail head shaped scratches are often found on the extremely hard gravels in the clay conglomerates, such as quartz sandstone, etc. Beneath the layer of clay conglomerates, peat and a sticky clay are sometimes found mixed together forming all types and all shapes of hard-to-describe, complicated small folds and derangements, which gradually disappear with depth. Also in the northwestern section of En-shih basin, very pronounced cleavages are found in the upper sections of hillocks formed by horizontal, soft red sandstone, and minor upthrust appear.

These surface structures are found with less frequency at increasing depth, and probably disappear completely at a depth of less than 20 meters from the surface. On the rock base where the clay conglomerates are accumulated, large frictional surfaces often appear. These frictional surfaces were clearly formed by very strong scraping and grinding actions.

The above described phenomena have been found in even more often in the western and northern parts of China in recent years, and they require a suitable explanation.

While manuscripts of this article were being prepared, the above mentioned type of frictional surface was again found in the western hills of Peiping on a flat slope at the northern side of the intermount basin where the Lung-en Temple is located. The structure of rock beds in the area definitely proves that this flat surface with its deep marks was not produced as a result of any structural movement of local rock beds or sliding movements along bedding planes. Smoothly spread over this frictional surface is a thin layer of fine and resiliently sticky greyish white clay.

Contained in this clay is a lot Sphagnum spores which are remnants of vegetation growing in coal and damp weather during the Quaternary period. The presence of this thin layer of clay proves that the marks on the frictional surface could not have been produced from slides of rocks and loose earth which had accumulated on top of the clay layer.

Considering these numerous facts together, the furnishing of accurate and definite conclusions is even more urgently called for.

(3) The problem of new structural movement. [Evidences of] Nes Structural Movements as advocated by Soviet scholars have been seen quite often in China during the past few years. In the area of the three rivers (Ching-sha Chiang, Lan-ts'ang Chiang, and Nu Chiang) in the southwest, the old rock beds show signs of new uplifts. The eastward turn of the northsouth flowing Ching-sha Chiang may have been caused by the latest uplift of the western section of Nan Ling's east-west belt. And the many violent earthquake areas of China's northwest and southwest all show evidences of all types and all shapes of New Structural Movement. However, our work has not yet advanced to the stage that we could clearly divide into stages and periods the New Structural Movement in China.

Neither are we able to classify the different types of New Structural Movement into different systems.

9. Problems in geodetic structure. The viewpoints and methods of China's geological workers in treating problems of geological structures are different. However, they may generally be divided into two factions. One faction arrives at the form, boundary, and period of existence of each structural unit by employing principally the viewpoint of sedimentation and utilizing the method that is close to ancient geography in dividing structural units. This faction sometimes calls itself or is called by others the geodetic structure faction.

The other faction identifies structural systems and structural forms on the basis of the formation of rock bed structures. This faction further arrives at the type of movement, especially its direction, an area went through in a certain geological age on the basis of the already identified structural form of the area. The working procedure of this latter faction places emphasis primarily on field observations. It analyzes from the mechanics viewpoint the different permanent deformations which took place in rock beds, such as compression belt, tensional facture belt, and torsional fracture belt, and the inter-relationship between them. The work of this faction is, therefore, sometimes considered by others as the work of geological mechanics.

In recent years we have studied the sediments of various geological ages by a method that is close to ancient geography, and a great deal of work has been done on the division of the earth strata, the changes in rock phases, and the identification of the ages of rock strata. This work is very useful in the study of sedimentary deposits.

However, this method is limited to describing a phenomenon and cannot explain the causes of the phenomenon. This type of working method implies that the base rock bed is a component part of the earth crust and that it is formed by earth blocks of different sizes and different hardness.

In our geodetic structure mapping work using this viewpoint as foundation, we have extensively applied [the theory] of deep and large fractures strongly advocated by some Soviet scholars. However, generally in differentiating the nature (tensional, compressional, and torsional) of the fracture and in searching for evidence as to the depth of the fracture, our work has not been sufficiently intensive or with great enough care.

Moreover, very little consideration has been given to the reason why a deep and large fracture in a certain location should extend in a definite direction and in a definite way. Actually, the above geodetic structure faction does not place any emphasis on the above key problems either, as far as other types of fractures are concerned.

In the division of earth blocks, there are often differences of opinion among our geological workers, although a unified opinion would be difficult. Nevertheless, this difference in opinion presents some difficulties in the work of compiling maps of geodetic structures.

Most of these numerous problems are common ones which concern the geological science of both China and the Soviet Union, and they are also general problems in geological science. The national boundary between the two very friendly brother nations of China and the Soviet Union is very long, and a very close relationship also exists in geology and in structures.

The two countries, therefore, must cooperate closely in order that these problems may be satisfactorily solved. Actually, the great cooperation in geological work between the two countries has already begun. For instance, the geological exploration work for the Hei-lung Chiang basin planning initially under the direction of "t'ung-hsun yuan-shih" [literally, communication member] P'u-ssu-t'o-wa-lo-fu is nearing its final stage. The study on the Pacific metallogenic belt as pointed out by academicia Ssu-mi-erh-no-fu has already been listed under items of Sino-Soviet cooperation and is being carried out.

Paleontological study and excavation work in Central Asia by China and the Soviet Union and other work of co-operation are also being carried out. Through this great cooperation, a deep friendship is continuously being strengthened between the geological workers of the two countries and a deep understanding has been reached.

Furthermore, in the work of research, both sides have been greatly benefited.

The geological work of the Soviet Union has had a very long history. Tremendous development and extremely glorious achievements have been made, particularly under the leadership of the Soviet Communist Party. The geological workers of China have been continuing the learning of Soviet advanced experiences without letup, and even more intensified learning will be carried out from now on.

Under the lofty banner of proletariat internationalism, close cooperation between the geological workers of China, Soviet Union, and other brother countries will be continuously strengthened. We believe that in this manner our geological work will make even greater contributions to the over-all development of geological science and will demonstrate its important significance in the great task of creating benefit to mankind.

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