ON THE LATE MESOZOIC-EARLY TERTIARY OROGENESIS AND VULKANISM, AND THEIR RELATION TO THE FORMATION OF METALLIC DEPOSITS IN CHINA

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CONTENTS

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1. INTRODUCTION

That there are close relations between Orogenesis, Vulkanism and formation of metallic deposits is unanimously accepted by geologists. Among the different metallogenetic epochs in China, the late Mesozoic and early Tertiary periods seems to have given the most important and at the same time the most varied metallization. It is remarkable to see that it is also during this period or periods, that the wide-spread orogenesis and vulkanism in China took place. In the present discussion, I am attempting to bring together some of the major facts in regard to these three most important geological processes and to see what relationship, if any, they may possess.

2. OROGENESIS

Thanks to the work of W. H. Wong[1], V. K. Ting[2] and J. S. Lee[3], the orogenic history of China is becoming more and more clear. In the present discussion, however, I shall limit my attention to the late Mesozoic and Early Tertiary orogenesis only, i.e. the Yenshan movement of W. H. Wong. In their latest discussion on the Yenshan movement, Wong and Ting subdivided it into three phases as follows:

Phase 3: Sharp folding and overturning in the orogenic zones ending in intense over-thrusting. Broad and gentle folding outside these zones. All took place in the Middle Cretaceous period.

Phase 2: Intense volcanic eruptions, granitic and dioritic intrusions in Upper Jurassic and widely in Lower Cretaceous.

Phase 1: Broad folding or warping at the end of Jurassic or the beginning of Lower Cretaceous.

The above classification is based on the assumption that all the Mesozoic volcanics, tuffs, agglomerates, porphyries, rhyolites etc were of the same age which is variously assumed to be Jurassic or Cretaceous. Recent studies by K. Chern and Y. S. Hsiung in the Western Hills* and by P. Kao[4] in eastern Chekiang, have definitely established the existence of at least two volcanic series separated by a marked unconformity. The lower one, consisting chiefly of agglomerate and andesite, which grades upward into a pyroclastic and clastic phase and contains at many places fossil fishes, *Cyrena*, *Estheria* etc, is most probably of Upper Jurassic to Lower Cretaceous age. This is equivalent to a part of the well known Tiaochishan formation in the Western Hills, or the Kienteh formation of Chekiang. The upper volcanic series is chiefly a rhyolite formation which at many places in S. and Central China is overlain unconformably by the red beds. Besides, in the Western Hills of Peiping, several more unconformities have been discovered both above and below the volcanic series, so that the Yenshan movement is really much more complicated than it at first appeared. In the Western Hills section, for instance, at least five phases may be distinguished, while in other regions, usually three or more have been described. A tentative correlation of the different phases is shown in Table I.

From this table it can be seen that three phases from 2-4 of the Yenshan movement are the most important and widespread ones, and are to be correlated with the phases I-III of Wong's original classification. The phase 1 seems to be restricted to the Western Hills and is more of epeirogenic rather than orogenic nature. The phase 5 is also widely distributed though rather of a gentle character; it marks the end of the Mesozoic orogenesis.

* Report not yet published.

Table 1 Late Mesozoic and Early Tertiary Orogenesis in China

	Western Hills (Several Authors)	Peipiao (Wong)	Eastern Chekiang (Kao)	Nanking Hills (Yih)	Shantung (Tan)	Weichang (Teilhard)	Phases of Movement	Wong's Classification
Eocene	......Warping Changsintien gravel (fossiliferous) ...Unconformity.		Basalt	Basalt Fanshan Gravel	I Kuanchuang conglomerate		Himalaya Movement ......Phase 5	
Upper Cretaceous	Hsiachuang (fossiliferous) Lushanwen Tuoli ...Unconformity.		Red Beds	Chihshan Pukow	Wangshih Series ...?	Conglomerate & gravel (Nantienmen	......Phase 4	Yenshan Movement: Phase III
Lower	Rhyolite etc ...Unconformity.	Upper Volcanic Series	Rhyolite	Dacite-Rhyolite Series	Chingshan or tuff conglomerate ...?	Rhyolite ...?	......Phase 3	Phase II
Cretaceous Upper-Jurassic	Hsinchuang Tahuichang (fossiliferous) Tiaochishan Kiulung ...Unconformity.	Upper Coal Series (fossiliferous) Lower Coal Series L. Volcanic Series	Shaohsing tuff Hutoushan conglomerate Juno (andesite etc)	Hsiangshan	Laiyang and (with fish) Meng-yin series (fossiliferous) Santai series (Red & green sandstone)	Lycoptera & insect beds Tuff conglomerate	......Phase 2	Phase I
Lower Jurassic	Mentoukou ..Disconformity.	Sinian			Fangtze Coal Series	Lingai Series		
Triassic	Diabase (partly intrusive & partly extrusive) Shuangchuan						......Phase 1	

The warping of the Changsintien, Fanshan and Kuanchuang gravel or conglomerate, all of which are here tentatively assumed to be of Eocene age, belong evidently to the Himalayan movement. Under this epoch again several phases may be subdivided as is evidenced especially by the Nanking Hills sections.

The age of the so-called red beds of South or Central China remains still an unsettled question. Field geologists have until now all assumed for it a late Cretaceous or early Tertiary age. Both in Hunan, Hupeh and perhaps Szechuan, field observations have recently established the existence of an unconformity within an otherwise monotonous red series. In Hunan and Hupeh fossils (fishes, plants in Hunan* and gastropod in Hupeh†) have been discovered in the younger horizon which is essentially horizontal and is very likely of Eocene age. If that is true, then the upper horizon may perhaps be correlated with the Changsintien gravels or Kuangchuang conglomerate of Northern China. The writer is therefore of the opinion that the red beds ‡ in the restricted sense, i.e. the lower, tilted sequence should belong entirely to Upper Cretaceous and can be tentatively correlated with the Tuoli group[5] of the Changsintien area, the Wangshih series[6] of Shangtung etc. With this assumption as basis, the above correlation table is prepared.

3. Vulkanism

By vulkanism it is meant here to include all kinds of igneous activities, both intrusion and extrusion. The igneous history of China is as obscure as that of the orogenesis; nevertheless, some essential features have already been worked out by various investigators; and these may be briefly discussed here. As is allowed by the scope and title of the paper, I shall limit my discussion again to the late Mesozoic and early Tertiary vulkanism only, which is a most remarkable epoch of igneous activities in China.

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* Discovered by the Tsinghua Students Party in 1934

† The fossil bearing limestone, the Yangchi limestone was first discovered by C. C. Liu and C. Y. Hsieh. (See Bull. Geol. Surv. No. 9, 1927). Recently it has been revisited by Teilhard and Young (See Bull. Geol. Soc. China, Vol. 14. No. 2).

‡ In my former communication, I have assumed the red beds of Hupeh to be of Tertiary age (see Bull. Geol. Surv. no. 9 Geology of Southwestern Hupeh.)

Table II shows succession and correlation of igneous activities in different part of China. Owing to lack of detailed facts, what is given in this table can only be considered as provisional. However, a few conclusion can already be obtained from a study of this tentative correlation.

(1) In the late Mesozoic time there were at least two periods of extrusion, separated by a marked unconformity. The earlier extrusion consists of agglomerate and andesite which grades upward into a sedimentary and pyroclastic phase. This is the Tiaochishan formation of the Western Hills and the Kienteh formation of the southeastern China. The later eruption is characterized principally by rhyolite and although several divisions of this group have been proposed by K. Chern in the Western Hills section, for general correlation they can be grouped together as a single unit. The geological age of these two eruptions can roughly be fixed as from Upper Jurassic to the end of Lower Cretaceous.

(2) The early Tertiary extrusion is very simple in composition consisting almost everywhere of a basaltic rock. The eruption took place probably in Oligocene-Miocene time.

(3) The nature and succession of the intrusive rocks are much more complicated. From the metallogenetic point of view, the basic intrusives can perhaps be excluded, since practically none of them have yielded any important metallic deposits. As to the granitic rocks, at least three or perhaps four types can be distinguished. These may be called: (1) The Mongolian granite of pre-Tiaochishan age. (2) The Lingsi granite[7] which is nearly contemporaneous with the great rhyolite extrusion (3) The grano-diorite intrusion which can perhaps be correlated with the Taitam formation of Hongkong and is of post rhyolitic and pre-Red beds age. (4) The Hongkong granite[8] which is the most widely distributed type in southern China dated perhaps a little later than the granodiorite but is still of pre-Red beds age.*

(4) The lamprophyre and other basic dikes mark the latest phase of the intrusion, with some of them extending even upward into the red beds. (as seen in Hunan and Hupeh).

* If the Tuoli group could be correlated with the Red Beds of Southern China then its post-granitic age should admit of no question. My former idea as to assume the Tuoli beds having been affected by the granite intrusion needs therefore further consideration.

(5) As has been stated before, the most intense orogenic movement took place in the post rhyolitic time, i.e. the phase 4 of the above table. It was also during this very epoch that most of the intrusive rocks like grano-diorite and Hongkong granite were formed. The pre-rhyolitic orogenic period or phase 3 was accompanied by the intrusion of the Lingsi granite and other basic intrusives while the intrusion of the Mongolian granite was perhaps caused by the pre Tiaochishan and Kiulung disturbance i.e. phase No. 2. Thus it is remarkable to see how close these two chapters of the geological processes, orogenesis and vulkanism are related to each other.

4. Metallogenetic Epochs

After the discussion of the orogenic periods and igneous activities, it is now fitting to inquire what would be the most important metallogenetic epochs in China and how are they related to the principal epochs of orogenesis and vulkanism.

A great number of metallic deposits like tungsten, tin, bismuth, molybdenum etc in southern China are genetically related with a granitic intrusion, the lithological characters of which are closely similar to those of the Hongkong granite. On the other hand, the numerous iron deposits of the Yangze Valley as well as the lead-zinc deposits of central Hunan are genetically related with an acid igneous rock which has been variously named as grano-diorite, diorite or quartz monzonite. It can perhaps be correlated with the Taitam formation[8] of Hongkong, and therefore its age of intrusion dated probably a little earlier than the Hongkong granite. The Lingsi granite with which the precious stone deposits of Suiyuan are probably related, has until now not yet been identified in central and southern China. The Mongolian granite which is probably equivalent to the Habota granite (in Jehol) of Teilhard,[7] forms probably the mother rock of the gold deposits. The same rock extend to the Three Eastern Provinces and Shantung as well as in the Tsingling since in these regions gold-bearing quartz veins are also widely distributed. The Kingpeng monzonitic granite in Jehol is yet difficult to correlate with any of the occurrences in southern China; from the occurrence of tourmaline, a mineral of pneumatolytic origin it may be suggested that this is essentially a type of Hongkong granite, since in the latter rock pneumatolytic action as evidenced by the occurrence of tourmaline together with other high temperature minerals is also well developed. Thus for the intrusive magmatic deposits, the following four metallogenic epochs may be distinguished:

Middle Cretaceous?	Epoch 4	Characterized by the high temperature deposits like tin, tungsten, bismuth, molybdenum and the low temperature phase antimony and mercury. Genetically related with the Hongkong granite.
	Epoch 3	Characterized by the contact pyrometasomatic as well as mesothermal deposits of iron, copper, lead and zinc, being genetically related with a grano-diorite intrusion, or the Taitam formation of Hongkong.
Lower Cretaceous	Epoch 2	The formation of precious stone deposits in Suiyuan. It is related with the Lingsi granite.
Upper or Middle Jurassic	Epoch 1	This is chiefly a period of gold formation associated with other metals like copper, lead, zinc and tungsten. The Mongolian granite forms the mother rock of these deposits.

As to the extrusive magmatic deposits two metallogenetic epochs may be distinguished; they are all unimportant and only the non-metallic mineral like fluorite is of some economic value. These two epochs are:

Early Tertiary	Epoch 6 —	Traces of copper, cobalt, and nickel forming amygdaloidal filling in basalt. Not important.
Lower Cretaceous	Epoch 5 —	Hydrothermal veins or deposits of fluorite in rhyolite, being the exhalation-effect of the rhyolitic eruption. This is the principal source of fluorite in China with Chekiang as the chief producer.

Thus there are altogether six metallogenetic epochs when both the intrusive and the extrusive types of deposits are considered together.

5. Metallogenetic provinces

The regional concentration of one or more similar types of mineral deposit is a fact that has now been widely recognized by geologists of different countries. To De Launy we owe the first introduction of the term "metallogenetic province". The existence of such similar provinces in China was first announced by W. H. Wong[9], who divided the different provinces and zones as follows:

3. Southern China Metallogenetic Province	d. Zone of Mercury c. Zone of Antimony b. Zone of lead, zinc and copper a. Zone of tin, tungsten, bismuth & molybdenum
2. Contact metamorphic province	This includes the famous iron deposits of the Yangtze Valley as well as some copper deposits of the same origin.
1. Pre-Cambrian metamorphic Provinces	A great variety of minerals are included such as gold, tungsten, copper, lead, zinc, and also non-metallic deposits such as asbetos, talc, magnesite, apatite, tourquois etc.

The different metallogenetic provinces herewith proposed are named according to their geographical position, no attempt is made to define the provinces or zones either by kinds of metals or by types of deposits. The reason is obvious because in each province there may occur several kinds of deposits of different origin. In the Nanling region, for instance, the high temperature deposits of tin, tungsten, bismuth etc may be associated with the low temperature type of antimony; such localization being chiefly dependent on their relative distances from the igneous mass (see fig. 1). In other words, zonal arrangement of various types of deposits may be expected in a very small area, such a case is clearly demonstrated in the region east of Yuanning, Kwangsi[10], South of Chenhsien, Hunan and in northern Chükiang; Kwangtung. On the other hand zonal arrangement on a large scale is also present, the most remarkable case being found in the four zones of southern China already so fully described by Dr. Wong. The writer, however, does not agree with him in the naming of the different zones by their characteristic metals. It is of course quite true that a certain metal or metals may be especially concentrated in certain zones, like the mercury of the Kweichow plateau, the antimony of western Hunan etc, but a strict exclusion of others is in most cases impossible. So in the case of western Hunan there occurs besides antimony, also abundant deposits of gold, copper and lead, all of which belong more or less to the same type of low temperature metallization. Therefore, in my opinion if any nomenclature besides the geographical one should be given to these different zones, they should be named according to their type of deposits, like the epithermal zone, the mesothermal zone etc, rather than the zone of antimony, the zone of lead and zinc etc.

In the accompanied map (Pl. I) the different metallogenetic provinces of the late Mesozoic and early Tertiary epochs are indicated. Meanwhile the map shows also principal physiographic units and important structural lines, the latter chiefly following the system recently proposed by J. S. Lee. From west to east these different provinces may be briefly described as follows:

1. Western Szechwan and northern Yunnan:—This is a complicatedly folded and faulted region with numerous igneous intrusions. The principal metallic deposits are copper and gold, of less importance are lead and zinc. The copper deposits of Tungchuan in Yunnan and Huaili in Szechwan all belong to pneumatolytic type with the characteristic gangue mineral tourmaline. The Penghsien copper deposit of Szechwan is of hypothermal type, with chalcopyrite and pyrrhotite as the principal ore. Gold quartz veins are found in the vicinity of Kengting and Tanpa in Hsikang district.

2. Kweichow plateau:—This is a high plateau made by strata of Palæozoic to Mesozoic age. Sharp and closed synclines of small magnitude are of frequent occurrence in an otherwise nearly horizontally bedded uplifted plateau. Igneous rocks are practically absent. Principal metallic deposit is mercury which is especially abundant on the northeastern, eastern and southeastern borders of the plateau, although scattered occurrences are also found in the center of the highland. This mercury belt partly extends to Szechwan in the north, Hunan in the east and Yunnan in the south, so it practically occupies the border land of these three provinces. As is well known in geology all

mercury deposits belong to the epithermal type, being situated very far from the igneous contact.

3. Western Hunan:—This region is characterized by high hills and deep gorges, a topography of slight dissection; it resembles in some respect a plateau although its relief is not as high as that of the Kweichow highland. It forms a transitional land between the Kweichow plateau to the west and the central Hunan hilly region to the east. The geological formations are principally of Palæozoic age forming gentle domes and synclines with only a few occurrences of igneous rocks. The region is richly mineralized, with antimony as the principal ore forming either replacement deposit or fissure-filling vein. The former type is represented by Hsikuangshan at Hsinhua and the latter type by Panchi, Yiyang. In both regions igneous rock is absent. Besides antimony, there are also gold, lead and zinc; the first named is more important and in the Yuanling and Taoyuan districts, gold quartz vein with albite, chlorite etc forms a very characteristic type. Sometimes both antimony and gold or even mercury may be found together in one vein. The lead-zinc deposits have not yet been carefully studied; most probably they represent also a mesothermal to epithermal type. The realgar and orpiment deposits of Tzuli and Shihmen represent also the characteristic mineralization of this region.

4. Central Hunan:—This region comprises central Hunan as well as the northeastern part of Kwangsi; it is made up chiefly of older Palæozoic formations which are intruded at many places by granite or grano-diorite. Closely associated with the intrusions is a series of lead-zinc deposits, with Shuikoushan in Changning as the leading example. The region has been affected by the Caledonian orogenic movement, but besides a few deposits like manganese, this movement seems to have had little influence on the development of metallic ores. The lead-zinc deposits are as a whole of mesothermal origin since only low temperature minerals like chlorite, epidot, sericite, quartz, fluorite, calcite are found among the gangues. On the other hand, a high temperature phase with the development of garnet, diopside etc previous to the episode of the main mineralization is also present, and as a last phase there may occur not infrequently an epithermal type with the formation of zeolite etc. Such a complete sequence has been recently identified in the Shiukoushan deposit.

5. The Nanling region:—As is indicated in the accompanied map the Nanling region comprises also the mountainous belt in central Kwangsi, because there the mineralization shows many similar features with that of the Nanling in the ordinary sense. Within the region considered, tectonic features are very complicated, with here and there large exposures of granite which are undoubtedly connected below to form a big batholith. In the granite or within its contact, a rich mineralization of tin, tungsten, bismuth and rarely also molybdenum is commonly found, all these deposits represent high temperature type being formed at considerable depth and under the active influence of the pneumatolytic agent. At some distance from the igneous contact, there may be found in the slightly altered sedimentary rock, replacement deposits or fissure fillings of lead, zinc and copper, and still further away from the igneous mass, antimony deposit may be found. Such an orderly arrangement of metallogenetic zones from the higher temperature type to the lower ones within an area of only a few tens of square kilometers is well displayed in the Nanling region. Best examples are to be seen in the vicinity of Chukiang, Northern Kwangtung, Chingchuantang, Chenhsien in southern Hunan and east of Yunning in central Kwangsi (Fig. 1). The Nanling region includes therefore a complicated series of deposits of different origin, but predominantly it consists of high temperature types.

6. Southeastern Coast:—This province includes the mountainous regions of eastern Chekiang, Fukien and southeastern Kwangtung. Geologically it consists of an immense field of extrusive rocks ranging in age from upper Jurassic to lower Cretaceous, and penetrated in many places by granitic intrusions of various sizes. The topography is bold and precipitous, presenting a youthful aspect. Metallic deposits are abundant and varied, but they are not as rich as in the Nanling region. Tin, tungsten, bismuth and molybdenum have all been found, the last named one, being specially important in the provinces of Fukien and Chekiang. Deposits of copper, lead, and zinc are also found, which from evidences at hand, seem to belong also to the high temperature type. The only important mineralization related to extrusive action seems to be the fluorite deposit, which finds its chief supply in the province of Chekiang. Within this region, hot springs are exceptionally abundant attaining in most cases very high temperature; they are indicative of the recent volcanic phenomena.

7. Shantung horst:—The shattered horst of Shantung is composed essentially of Palæozoic-Mesozoic formations in the west, and pre-Cambrian mass if with granitic intrusions in the east. Metallic deposits, chiefly gold, are especially abundant in that pre-Cambrian land, being genetically related to a granitic intrusion of at least post Gneiss or perhaps late Mesozoic age, therefore the gold deposits of Shantung are much younger in age than was formerly thought. Most eminent example is the deposit of Chaoyuan which has been mined for a long period of time.

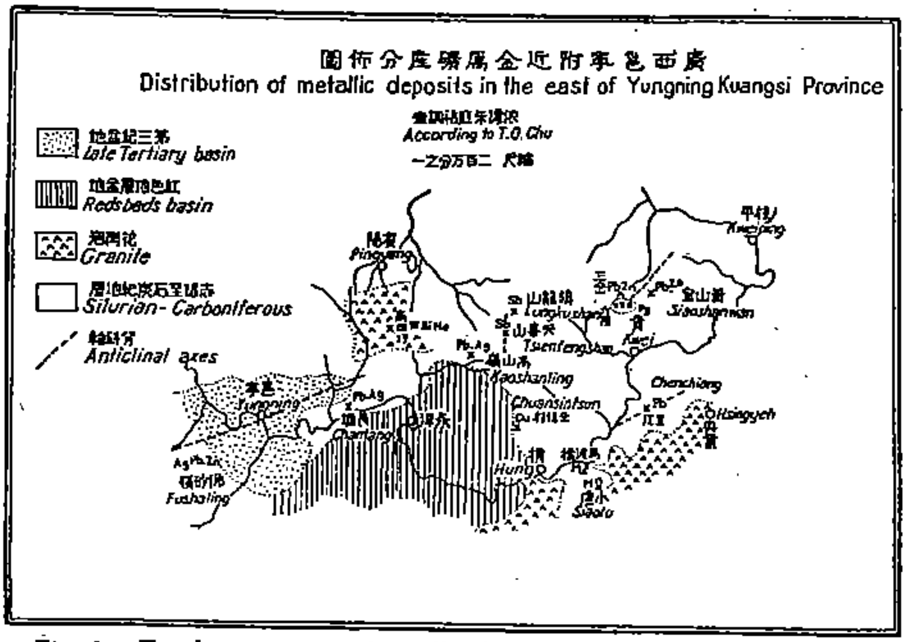

Fig. 1. Zonal arrangement of metallic deposits near Yungning, Kwangsi.

8. Border zone of Shansi and Kweichow plateau:—From a glance at the accompanied map, one will notice at once the symmetrical position of the two plateaus, the Shansi plateau in the north and the Kweichow plateau in the south. The eastern border of these two plateaus show in many places a dislocated zone and closely associated with it are a number of copper, lead and zinc deposits, all being in sedimentary rocks, and very far from any of the igneous exposures. Noted examples are the copper deposits of southern Shansi and northern Honan, the copper and lead deposits of northwestern and southwes-

Table II The Late Mesozoic and Early Tertiary Vulkanism in China

	Western Hills region of Peiping (K. Chern)		Weichang Area, Jehol (Teilhard)		Hongkong (Uglow etc)		Nanking Hills (Yih & Yu)		Eastern Chekiang (P. Kao)	
	Extrusive	Intrusive	Extrusive	Intrusive	Extrusive	Intrusive	Extrusives	Intrusives	Extrusives	Intrusives
ly Ter-ary			Basalt				Basalt		Basalt	
perCre-taceous	Touli group (Sedimentataries)		Conglomerate & gravel		Junk Bay formation, conglomerate, tuffaceous sandstone argillites	Lamprophyre dikes	Chihshan red beds Pukow red beds		Red Beds= Kiangkow series (Purple tuff ss, tuff conglomerate red shales etc.	Lamprophyres
	Unconformity	Aplites & pegmatites	Unconformity		Unconformity	Lantau intrusion (granite porphyry) Hongkong Granite	Unconformity	Aplite intrusion (quartz porphyry included)		
ldle aceous)		Andesite dikes & lamprophyre Granite intrusions (4 types are distinguished)		Kingpeng monzonitic granite with tourmaline		Taitam formation (granodiorite, porphyritic hornblende granite porphyry)		Gabbro-diorite & dikes of lamprophyre Grano-diorite intrusion		Granite intrusion
ver aceous	Tunglangkou Agglomerate & andesite		Andesite (Pei-Piao)		Rocky Harbour Volcanics a dark colored aphanitic rock with phenocrysts of pink feldspar & quartz					
	Green rhyolite & pyroclastics		Great Rhyolite Extrusion	Dikes of basaltic andesite at Linyuan						
	Tunglingtai {Rhyolite, trachyte, agglomerate, tuff also tuff, sandstone and shale}			Lingsigranite, pegmatitic with smoky quartz, Probably equivalent to Suiyuan granite with topaz-Beryl.			Dacite Rhyolite Series {Dacite flow, Dacite tuff, Rhyolitic tuff, Rhyolitic flow}		Rhyolite	
	Unconformity		Unconformity		Unconformity				Unconformity	
per ssic	Tiaochishan {Andesite, Agglomerate}		Trachyte, Andesite,	Dikes, laccoliths etc of andesite Biotite granite of Mongolian pla-[illegible]	Repulse Bay volcanics. Lava (felsite, quartz porphyry) agglomerate, tuff, ash [illegible]	Taimoshan Intrusion (Necks, Sills, dikes) quartz porphyry to granite porphyries	Hsiangshan formation (equivalent to uppermost part of Tiaochishan with Estheria etc.		Shaohsing tuff Hutoushan conglomerate Juao volcanic series	

tern Hupeh respectively. The origin of these deposits still remains obscure; probably they are the product of cold water deposition, the source of the metals being chiefly from solution and concentration of such trifling amounts as were originally contained in the country rocks. Their genesis is therefore closely comparable with the Mississippian lead-zinc deposits of the United States.

9. Hopei-Jehol border land:—In this region gold is the most important deposit with also some lead, silver and zinc, the last three being chiefly found in Jehol. Associated with gold occurs occassionally some tungsten. In the lead-zinc deposits, lead is usually more abundant than zinc, a feature just in contrast with those deposits found in Central Hunan. The geology consists essentially of pre-Cambrian schists and gneisses intruded at many places by granite of different generations with one of them appears to be pre-andesitic and is therefore of pre-Upper Jurassic age. Only the type just named seems to have developed any metalliferous deposits.

10. Liaotung region:—This includes the mountainous region east of the Sungliao plain. The geology appears to be quite complicated by faultings and foldings, but the formations are more or less similar to those seen in northern China. Igneous intrusions and extrusions are abundantly represented. Unlike other northern-China provinces, the Liaotung region is richly mineralized especially in iron. The most noted examples are the iron deposits of Anshan and Miaoerhkou, both of which have supported now a modern iron industry of considerable importance. The origin of these deposit is exceedingly interesting because it shows in certain phases similar development to the Lake Superior iron deposits of the United States. The formation of the proto-ore as well as the secondary enrichment must have been well completed in the Pre-Cambrian time, but later enrichment caused by magmatic activities in the late Mesozoic-Early Tertiary periods may be also of some importance. Besides, there are abundant occurrences of gold, copper, lead and zinc; but none of them seem to have given any important production. The characteristic deposits of the Nanling region like tungsten, tin, bismuth, antimony, mercury etc are conspicuously absent.

11. Yangtze Valley:—Iron deposits formed as an after-effect of the grano-dioritic intrusion constitute the principal mineralization of the region. Several types varying from contact pyrometasomatic to hydrothermal may again

be divided. At Tayeh and Yangsing in southeastern Hupeh, the same magma has developed a copper deposit at its contact with the Permian limestones.

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