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THE
GEOLOGY OF HSI-SHAN OR THE WESTERN HILLS
OF
PEKING.

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CHAPTER I.

STRATIGRAPHY.

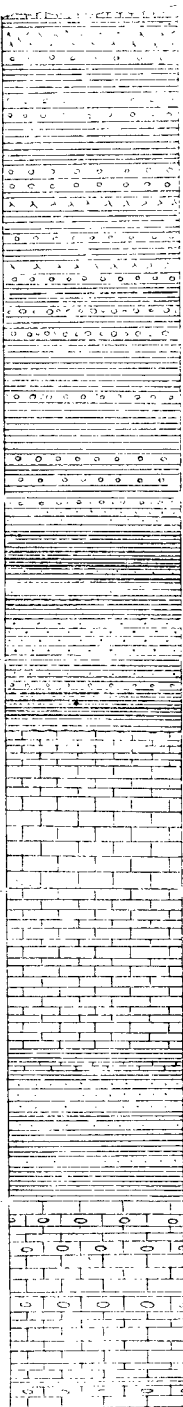
Within the relatively small area to be dealt with in this paper, most all the important sedimentary formations of northern China can be observed except the Archean and the metamorphic Algonkian. Owing to the existence of successive synclinal and anticlinal foldings and several important faultings, the same formations are often repeated in outcrops. As is the general case in northern China, the sedimentary series do not represent a continuous stratigraphic sequence but are separated by several deceptive conformities. They may be systematically treated as follows.

NEO-PROTEROZOIC

Siliceous Limestone.

Occurrence.—The siliceous limestone is exposed in a semi-dome-like mass extending from north of Kao-Yai-Kou (高崖口) Fang-Liang-Tsun (方梁村) and Ta-Tsun (大村) southwestward to Ching-Pai-Kou (青白口) thence northwestward to Hsiang-Yang-Kou (向陽口), dipping toward SSE and SW at varying angles of 10° to 60° . Farther west and north from Ching-Pai-Kou and northeast from Kao-Yai-Kou it extends to Pei-Yü (柏峪) and Nan-Kou (南口) respectively. (see plate XIII.) Besides this extensive mass, it crops out at an isolated hill near Liang-Hsiang (良鄉) station of Peking-Hankow railway in the far southeast corner of the surveyed area. About 32 li north of this hill occurs another exposure of the same formation.

Characters.—This limestone is either blue or light gray, or less often, dark gray in color. It may be either thick- or thin-bedded. It is characterised by abundance of chert, either in nodules or in thin lenticular bands. In some parts, however, the limestone may be quite free from chert. Thin black shales interbedded in the limestone have been recognised on the route from Ta-Tsun to Hsiang-Yang-Kou. The base of this formation has not been seen within the limit of the mapped area, but in other localities, Nan-Kou, Hsuan-Hua (宣化), etc., it is underlaid by a quartzite. According to the northwestern exposure it has a probable thickness of about 1000 meters.

Geological Period	Formation		Metres	Description
Pleistocene and Pliocene	Unconformity		?	Present land surface Variegated clay, stratified gravel and loess.
Upper Jurassic	Tiao-Chi-Shan Formation		1500	Porphyry lava, porphyry conglomerate, g. and red shale, yellow sandy shale with le. of coal, and conglomerate of porphyry, lime one and marble pebbles.
Lower Jurassic	Unconformity			
	Kiu Lung-Shan Series		700	Violet and green shale, sandstone, and conglomerate.
	Men-Tou-Kou Coal Series		550	Conglomerate, coal-bearing sandstone and shale.
Permian-Triassic	Unconformity Hung-Miao-Ling Sandstone		130	Quartzose sandstone.
Carboniferous	Yang Chia-T'un Coal Series		3.0	Shale, sandstone, coal & conglomerate.
Ordovician	Unconformity			
	Upper S'nian		750	Massive, dark blue Actinoceras limestone. Only the upper part is thin-bedded.
Cambrian	Lower S'nian		900	Wurmikalk, oolitic limestone, reddish and greenish shale in which a bed of dolomitic limestone is intercalated.
	Unconformity			
Pre Cambrian	Hsia-Ma-Ling Formation		570±	Sandstone, carbonaceous shale and slate.
	Slieeous Limestone		1000±	Slieeous limestone interbedded with thin bands of chert and black shale.

Total approximate thickness...6600 m.

Fig. 1. Generalized section of sedimentary rocks of the Western Hills, Peking

Hsia-Ma-Ling (下馬嶺) Formations.

Occurrence and stratigraphic relations.—Lying conformably on the siliceous limestone is a formation, of which the lower part consists of carbonaceous slates and shales, while its upper part is a blackish yellow, coarse sandstone with brown weathered surface. From north of Ta-Tsun southward to Ching-Pai-Kou it is continuously exposed above the siliceous limestone. North of Ta-Tsun it is cut by a fault. Northwest of Ching-Pai Kou it probably extends out to adjoin the outcrop of the same formation at Pei-Yü (柏峪) that was first seen by Richthofen.

In the valley of a tributary of Hun-Ho (渾河) from Tien-Chia-Chuang (田家莊) to Hsia-Ma-Ling, where this formation was first seen, the uppermost sandstone has been turned vertical and the overlying formation, a limestone, was thrust against it (fig 2). On the north side of Hun-Ho and opposite to Chin-Yü-Kou (芹峪口) a section is exposed as shown in Fig 3. The Hsia-Ma-Ling (下馬嶺) formation is there conformably lying under a red shale, which is the lowest member of the Cambrian system. North of Tai-Tze-Mu (太子墓), its contact with the siliceous limestone is clearly exposed. The lowest shale is a little limonitic. Along Ching-Shui-Ho (清水河) near the village Ching-Pai-Kou (青白口), the black shales and slates are very carbonaceous and strongly folded (Fig 4). A little SE from Ching-Pai-Kou, there is a valley called Liu-Kung-Kou (劉公溝). On the NE side of which a section is seen as in fig 5. The whole formation has a varying thickness in different places. At Hsia-Ma-Ling it seems especially thick, about 700 m. At Fu-Chia-Tai (傅家台) and Ching-Pai-Kou, it is about 450 m. Natives of Ching-Pai-Kou village, took this formation for a coal bearing series and prospecting has been carried out in several points, but they failed to get anything.

Age and Correlation. Up to the present no fossils have been found in these formations. In the year 1871 F. von Richthofen during his journey from Chai-Tang (齋堂) to Fang-Shan-Pu (礮山堡) and also in the Nan-Kou pass saw a siliceous limestone §) and he included it in his

§). China Vol. II page 306-307.

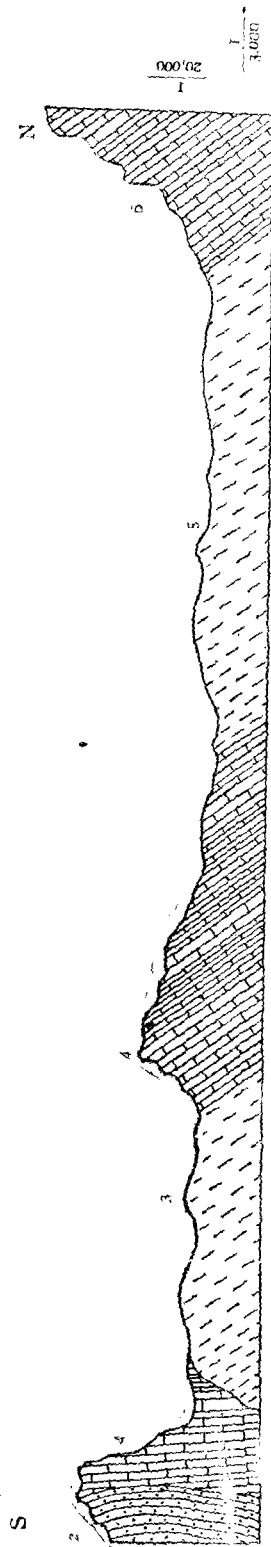


Fig. 2 Section two li NE of Chin-Yü-K'ou (口哈芦).

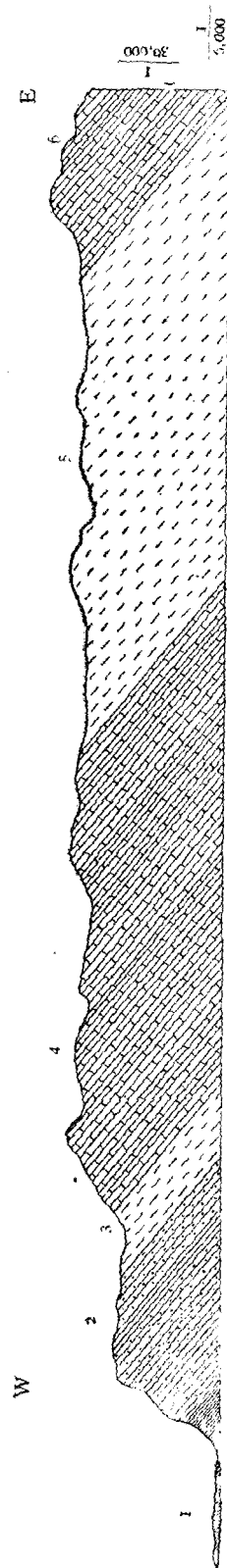


Fig. 3 Section north of Hun-Ho (河滩) and Opposite to Chin-Yü-K'ou.

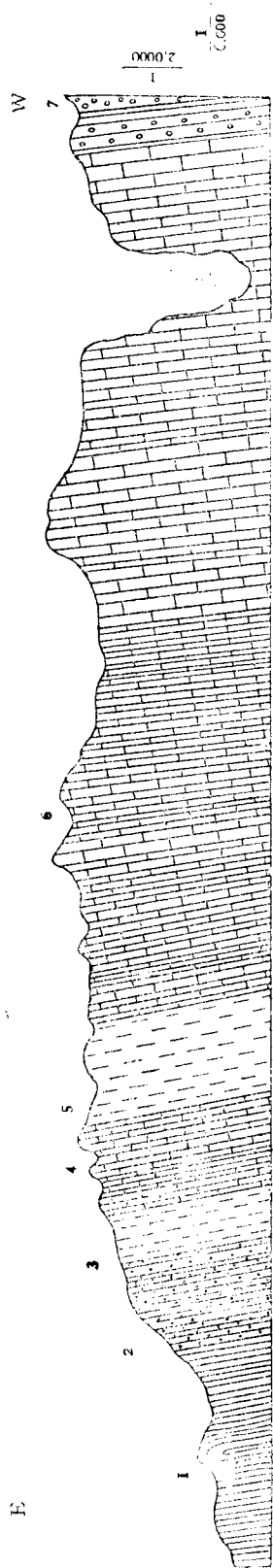


Fig. 4 Section South of Ching-Shui-Ho (河水清) near Ching-Pai-K'ou (口白青)

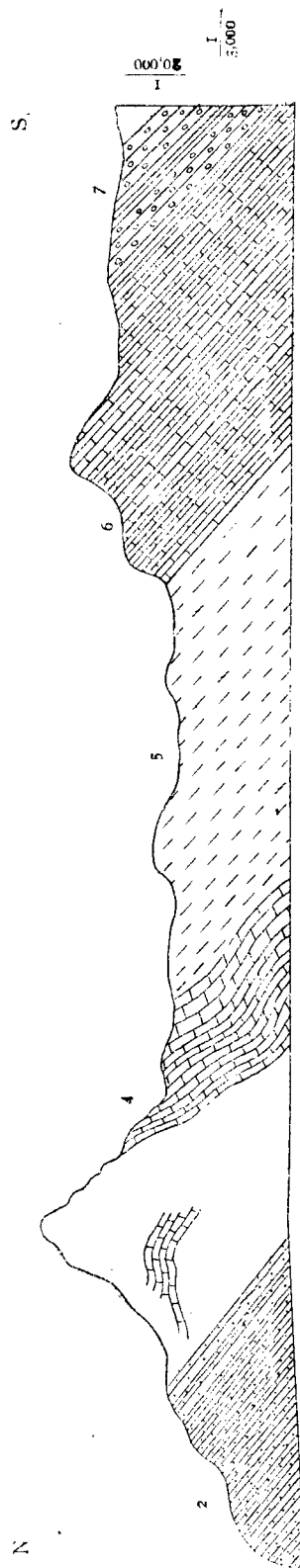


Fig. 5 Section on north-east side of the valley, Liu-Kung-Kou (溝公劉) South of Fu-Chia-Tai (合家傅)

- Pre Cambrian :—1. black shale
 2. Sandstone
 Cambrian :—3. lower red and green shale
 4. middle limestone
 5. upper red and green shale
 6. Oolitic limestone and Wurmkaalk.
 Jurassic :—7. porphyry conglomerate

Sinian system (Cambrian). Since the Carnegie Expedition to China in 1903-04, flinty limestones are known to occur both in Shansi and Chihli, where they were respectively designated under the name of Hu-T'o system and Ta-Yang limestone; the latter, B. Willis and E. Blackwelder assumed to be correlatable with the flinty limestone of the Hu-T'o system and that of the Nan-Kou pass §§) observed by von Richthofen. They have proved these limestones to be of Pre-Cambrian age, since the "Ta-Yang limestone is separated from the Archean below and from the Cambrian above by pronounced unconformities" §1). In view of its similarity in character and the nearness of occurrences, the siliceous limestone of Hsi-Shan is doubtless the same as the Nan-Kou limestone of Richthofen, and is of pre-Cambrian age as proved by B. Willis and E. Blackwelder.

But, neither von Richthofen nor the geologists of the Carnegie Expedition have seen such a series as the Hsia-Ma-Ling formation, exposed between the Cambrian red shale and the siliceous limestone in the same locality. Von Richthofen did see a formation of sandstone and shales at Pei-Yü (柏峪). Unfortunately it is separated from the red shale above by 400 m. of dense gray limestone, §2) though it is in contact with the siliceous limestone below. Lately Mr. V. K. Ting, Director of the Survey, has restudied the section observed by von Richthofen, and has found that he misunderstood its real structure. The section is practically as fig. 6. In reality the sandstone and shale of Pei-Yü are also intercalated between the red shale and the siliceous limestone. It is therefore identical with the Hsia-Ma-Ling formation. As to its age we can do no better than follow the assumption of E. Blackwelder and B. Willis that it is the upper member of Ta-Yang limestone §3), which had been eroded in the sections observed by them, i.e. it is also of pre-Cambrian age.

§§). Research in China Vol. I part II page 10.

§1). Research in China Vol. I part I page 131.

§2). China Vol. II page 306.

§3). Research in China Vol. I part I page 10.

PALAEOZOIC.

CAMBRIAN.

Lower Sinian.

Occurrence.—North from Yü-Ni-Keng (淤泥河) southwest to Ching-Pai-Kou there is a continuous belt of lower Sinian formation which rests on the Hsia-Ma-Ling series as has already been referred to. (see fig 2-5). It is unconformably covered by a Jurassic conglomerate. Evidently it has been subjected to prolonged erosion which must have taken away a part of the strata, so the section here is not complete.

Characters.—The lower Sinian formation comprises 5 minor divisions. They are from bottom upwards, (1) lower shale, usually purple, sometimes green, (2) middle limestone, (Pl. I A) the upper part being thick-bedded and gray in colour, the lower part, greenish white or reddish white and thin-bedded, usually rather pure, (3) upper shale similar to (1), (4) dark or light gray limestone, hard and dense, partly crystalline and oolitic in texture, and (5) conglomeratic limestone or wurmkalk, dark or yellowish gray. Sometimes it is difficult to separate (5) from (4) ex. in the exposure west of Tien-Chia-Chuang a bed of typical wurmkalk, about one foot in thickness is found to be intercalated between typical oolitic limestone. The oolites are usually not more than 1mm diameter, but occasionally, as in a bed east of Chin-Yü-Kou (芹峪口) they may reach the size of about $\frac{1}{2}$ cm. In the same formation along Ching-Shui-Ho, the oolitic and the conglomeratic textures are not clearly seen. Here the uppermost part of the lower Sinian seems to be particularly thick. Probably it is transitional to the upper Sinian. Several sections have been measured. Their thickness are approximately as follows:

Locality.	Lower shale	Middle limes.	Upper shale	Oolitic and Cong. lim.
North of Chin-Yü-Kou ... (fig 2)	70m	90m	170m	
East of " " " ... (" 3)	25m	180m	190m	220m
Along Liu-Kung-Kou... (" 5)		100m	100m	90m
South of Ching-Shui-Ho ... (" 4)	45m	100m	100m	770m

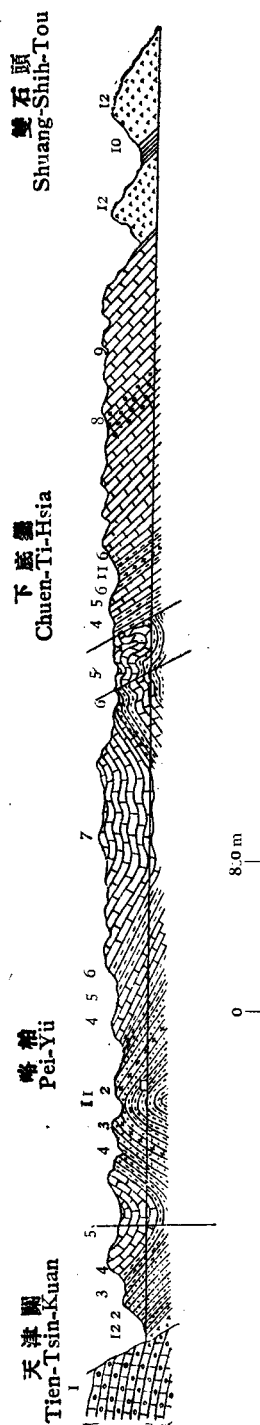


Fig. 6. Section North of Chai-Tang (寨堂), by V. K. Ting. Pre-Cambrian:—1. Siliceous limestone, 2. black shale, 3. ferrogneous sandstone; Cambrian: 4. reddish and greenish shale, 5. white limestone, 6. reddish and greenish shale, 7. oolitic limestone; 8. Wurmshank; Ordovician: 9. dark blue limestone, Mesozoic: 10. Jurassic coal series, 11. diabase and andesite dikes, 12. porphyry.

It seems that the lower shale does not exceed 100m in thickness, the middle limestone is always about 100m, the upper shale is thicker than the lower shale, and the uppermost limestone is varying in thickness according to the degree of erosion.

Mr. V. K. Ting has noticed that the Cambrian system exposed in the section north of Chai-Tang is also composed of the same subdivisions as described, which Richthofen did not know because of his misunderstanding of the local structure. (Fig. 6.)

ORDOVICIAN.

Upper Sinian.

Occurrence.—The largest exposure of the upper Sinian formation lies in the southwestern part of Hsi-Shan. It forms the most barren and precipitous mountains; the highest and longest ridge composed of this limestone is called Hua-Mu-Ling (花木嶺). On either side of Hun-Ho above San-Chia-Tien (三家店), the same formation also extensively occurs: in the pagoda hill or Yü-Chuan-Shan (玉泉山), in the neighbourhood of Wen-Chuan-Ssu (溫泉寺), Pai-Chia-T'au (白家疃), Yang-Fang (羊坊) etc.; in the west and northwest of Fang-Shan-Hsien (房山縣) city, and in the north of Ching-Shui-Ho (清水河) valley near Chai-Tang, occurrences of this formation can also be found.

Characters.—The upper Sinian formation is a limestone, usually massive either black or dark gray or grayish white in colour. Exceptionally it is so thin bedded that it looks like slate, and somewhat siliceous. Below, it passes insensibly into the lower Sinian, for instance, in the valley from Tan-Li (旦里) to Nan-Chuang (南莊) and in the deep valley from Ho-Pei-Tsun (河北村) to Tih-Shui-Yai (滴水崖); above, it is often succeeded by a coal series of Carboniferous age. Its contact with the latter is generally irregular in outline having depressions filled by red clay.

In the region of An-Tze (安子) and Nan-Chiao (南窖) the limestone conformably underlying the carboniferous coal series is mostly massive, black or grayish white in colour, and very pure in composition. Only its uppermost portion is rather thin-bedded. The same limestone in Tung-Shan-K'ou (東山口), Chin-Ling (金陵), Yang-Erh-Yü (羊耳峪) etc., lies in contact with granite so it has been converted into marble. Near Shi-Pu (石堡), the uppermost Sinian is more shaly than any other exposure. It yields garnet crystals and has been deeply weathered. In the districts of Shih-Ta-Pei-Shan (四大背山), Tieh-Shih-To (鉄石坨), Pe-Yü-Kou (北峪溝) and Lung-Chuang-Ho (龍泉河) or Liu-Li-Ho (琉璃河) the upper Sinian formation is best developed. It is dark gray to black in colour. On either side of Liu Li Ho (琉璃河) it becomes a white or grayish white marble somewhat dense, and rather pure. South of that river it everywhere underlies the Carboniferous coal series. From Tih-Shui-Yai to Pan-Ko-Chuang (班各莊), it has been thrust against the latter. In the valley of Nang-Kiang-Kou (南港溝) south of Cbuang-Hu (莊戶), it is less pure than usual. A bed of calcareous shale and thin layers of yellowish dolomite are interbedded between massive dark gray limestone. The same applies to the limestone near Hsin-Fang (新房) south of T'an-Che-Ssu (檀柘寺) where the lime burnt from the reddish limestone is gray and earthy, while that from the dark blue variety of the same locality is clean white. On the eastern end of Ma-An-Shan (馬鞍山) the blue limestone is traversed by a multitude of fine calcite veins and is partly brecciated. In Ta-Chiao-Ssu (大覺寺), Wen-Chuan-Ssu (溫泉寺), and Shan-Wei-Tien (上韋甸), a part of the upper Sinian formation had been metamorphosed into marble through the intrusion of granite bodies. The thickness of this formation is roughly estimated at about 750 m.

Age and Correlation.

Trilobites are quite common in the oolitic limestone and several collections have been made, for example, near Tien-Chia-Chuang and north of Ch'ai-Tang. *Actinoceras* has been recognised in the upper Sinian limestone in different localities by different members: Mr. C. C. Liu saw it in a place southwest of Shih-Tze-Tao (十字道), Messrs. C. Y. Hsieh and T. Y. Loo discovered it in Nan-Kiang-Kou (南港溝) valley south of Chuang-Hu (庄戶) and Chien-Chun-Tai (千軍台), and Mr. H. C. T'an found it on the summit of Tih-Shih-T'o (鉄石它). As shown in the map, all these localities are rather near to one another. It seems probable that they all belong to the same horizon.

What has been designated by von F. Richthofen as "Sinische Formationsreihe" in Shantung includes all the strata of Cambrian age and also the siliceous limestone then supposed to be Cambrian. The Ordovician limestone has been miscalled by him *Kohlenkalk*§). The Sinian system as used by B. Willis and E. Blackwelder consists of the Manto-shale and Kiu-Lung limestone of Cambrian age, and the Tsinan limestone of Ordovician age in the province of Shantung; while in Chihli and Shansi, it comprises the Cambrian Manto shale and the Cambro-Ordovician Ki-Chou limestone which cannot be subdivided so readily as in Shantung into the Kiu-Lung and Tsi-Nan groups, though it possesses most of their characters. In Hsi-Shan, the Cambrian and the Ordovician formations are on the whole similar to that of the latter regions, and therefore without doubt they can be correlated with the Sinian system of B. Willis and the corresponding part of Richthofen's "Sinische Formationsreihe", but the lower part of the Cambrian in the region discussed is rather constant in composition, always consisting of a lower red shale, a middle limestone, and an upper red shale; and the *Actinoceras* limestone is especially thick. Moreover, in this region the red shale formation occurs everywhere together with the oolitic limestone; but the *Actinoceras* limestone is often extensively exposed without the oolitic group. So here it is desirable to keep the two main divisions separated: lower Sinian corresponding to the Cambrian formations, and the upper Sinian the Ordovician limestone.

§) China Vol. II page 226 and 301.

CARBONIFEROUS.

Yang-Chia-T'un (楊家屯) coal series.

General Statement.—Through a hiatus covering the history from upper Ordovician to the end of Devonian, the upper Sinian formation is succeeded by a Carboniferous series which is composed of sandstone, slates, anthracite bearing shales and conglomerates. In some localities, it has been partly metamorphosed to schists. The number and thickness of coal seams vary in different places. As far as it can be judged from the position of the old pits, I have the impression that the workable coal seams are always below a thick bed of conglomerate and generally confined to the lower portion of the series. Two samples from a native pit in Hui-Yü (灰峪) near Yang-Chia-T'un, have been analysed. Their composition is as follows:

	Nature	Moisture	Volatile Mat.	Ash	Coke
Sample I (upper seam)	non-caking	1.18	6.22	26.08 (grav)	92.60
Sample II (lower seam)	„	1.32	5.96	24.20 (flesh)	92.72

Though these two samples cannot be taken to represent the whole, the Carboniferous coal§ of Hsi-Shan as far as the present knowledge goes is of low grade. The thickness of the whole series varies in different districts. It is about 350 m. thick at An-T'an (安灘), 440 m. at Yang-Chia-T'un, 250 m. at Wan-Fo-Tan.

Occurrence.—Around the syncline of Kiu-Lung-Shan (九龍山), west of Men-Tou-Kou railway station the Carboniferous coal series is everywhere exposed. It lies directly on the upper Sinian limestone and below a quartzose sandstone which is thought to be of Permo-Triassic age. Along this outcrop zone, there are three segments where this series seems to be comparatively thicker and more productive. Consequently it has been and is still worked by many native pits. The nearest one to the Peking-Men-Tou-Kou branch line is the valley of Liu-Li-Chu (琉璃局) north of Kiu-Lung-Shan. The second segment includes the portion between Wang-Ping-Tsun (王平村)

§ See Chapt V.

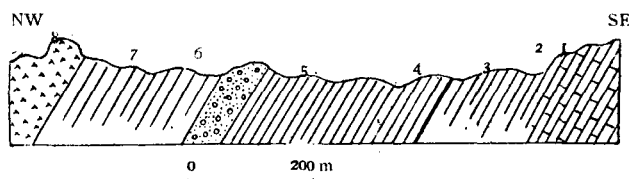


Fig. 7 Section of Yen-Li-Kou (言李溝), SW of Wang-Ping-K'ou (王平口).

Ordovician:—1. dark blue limestone.

2. Yellowish dolomitic limestone.

Carboniferous coal series:—

3. black sandy slate, 4. Anthracite seam, 5. black shale,

6. conglomerate, 7. black sandy slate.

Jurassic—8. diabase.

and Wang-Ping-K'ou (王平口), and the third lies in the north of Chieh-Tai-Ssu (戒台寺). In a valley called Yen-Li-Kou (言李溝) south of Wang-Ping-Kou, a section of the coal series was observed as shown in fig. 7. which may represent the series in general.

From Liu-Li-Chu eastward and on the other side of the Hun-Ho river it is again exposed between Yang-Chia-T'un and Chai-K'ou (寨口). This seems to be the east extension of the Liu-Li-Chu outcrop. At Yang-Chia-T'un the series itself is strongly distorted and faulted. Four seams of anthracite are known to occur on either flank of a minor syncline. Each has a thickness of about 5-6 ft. It was told by the natives that when descending deep into the ground, 4 seams are united to one from 10 feet to 20 feet thick. After an interruption by alluvium east of Chai-Kou it continues southeastward to Hei-Lung-T'an (黑龍潭) and Pai-Chia-T'an.

Northwest of Fang-Shan-Hsien city, occurs another synclinal basin that I designate as Pei-Ling syncline, around which the Carboniferous coal series overlies the upper Sinian limestone. Its lower part consists of dark gray or greenish gray coal bearing shales and slates which generally have been metamorphosed and yield cubes of pyrite, whereas in the vicinity of granite intrusion, §) andalusite, chiastolite and garnet schists have been found in the lower part of the series. The thickness of the coal is not more than 5 feet. The exact number of seams is uncertain, probably only one. The quality of coal is said to be much inferior to that of Liu-Li-Chu, Wang-Ping-Tsun, Yang-Chia-T'un etc. At Chow-Kow-Tien (周口店), it is particularly poor.

§) See Chapt. II.

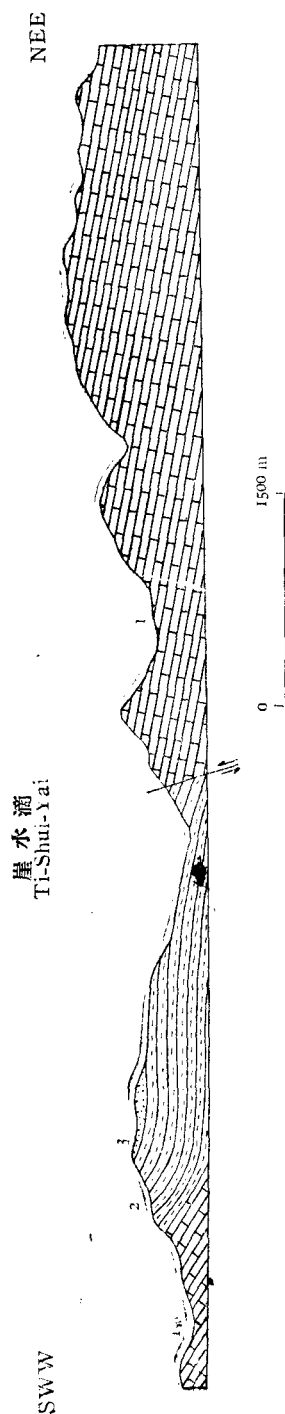


Fig. 8. Section near Tih-Shui-Yai (H. C. Tan) 1. Ordovician limestone, 2. Carboniferous coal series, 3. Permian-Triassic sandstone.

Natives call it Ching-Hui (青灰), or blue ash because it contains so much of the latter that it can only be used for limeburning when mixed with good coal. The upper part of the coal series is composed of conglomerate, shale, and sandstone. The last one had been metamorphosed to quartzite in the east of Tung-Shan-K'ou, north of Chow-Kou-Tien.

From Fu-Tzü-Chuang (佛子莊), and Hei-Lung-Kuan (黑龍關) on the northern rim of the syncline, there is a stretch of the series striking northward to the village of Tih Shui-Yai. Thence, it turns toward Ta-An-Shan (大鞍山). This whole extension had been faulted down so as to dip against the upper Sinian limestone on the north and the east side (see fig. 8). From Fu-Tzü-Chuang westward to Hung-Mei-Ch'ang (紅煤廠), and further west to Liu-Lin-Shui (柳林水) and Yuan-Yang-Shui (鴛鴦水) there is another prolongation of the outcrop. Within these two extended areas the Carboniferous series is composed of black shales and schists, commonly the garnet schist, but seems not to bear any workable coal.

Northwest of Hua-Mu-Ling is the syncline of Miao-An-Ling and Ching-Shui-Chien (清水尖). On its south-east limb a long strip of the coal series occurs above the upper Sinian limestone from Chin-Chi-Tai (金鷄台) to Wang-Ping-Tsun. Only in the portion from a little south of Ta-Han-Ling (大寒嶺) to the village of Wang-Ping-Tsun, one seam of anthracite about 10 feet thick is known to exist below a thick bed of conglomerate.

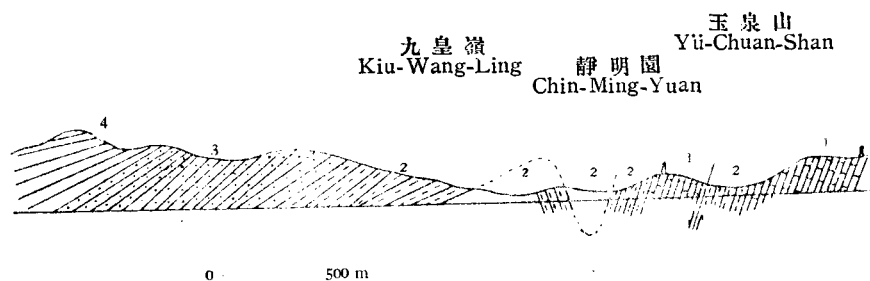


Fig. 9. Section of Yü-Chuan-Shan (玉泉山).—1. Ordovician limestone, 2. Carboniferous coal series, 3. Permo-Triassic sandstone, 4. Jurassic green and violet shales.

Besides, in the Yü-Chuan-Shan or Pagoda Hill and its neighbourhood a sequence of greywacke and carbonaceous shale is exposed, (see fig. 9). East from Ta-Hui-Ch'ang to the west of Mei-Ling (煤嶺) there is also a belt of the Carboniferous formation above the upper Sinian limestone forming the southeast rim of Hua-Mu-Ling dome that has been already referred to.

Age and Correlation.—Plant fossils have been found from different localities. In Yang-Chia-T'un, they are:—*Calamite* sp., *Annularia* sp., *Sigillaria* sp. etc.

In Liu-Li-Chu, *Annularia* sp., *Neuropteris* sp. etc.

In Cbow-Kow-Tien, *Pecopteris* sp., *sphenopteris*, *Annularia* sp. and *Neuropteris* sp.

This Carboniferous formation can be roughly correlated with all the coal bearing series of the same age in Shantung, Shansi, Honan, and other parts of Chihli, though the different horizons may not be comparable in detail. Some striking differences should also be noticed: Firstly in thickness, in the number of seams as well in quality, the Carboniferous coal in Hsi-Shan is inferior to the corresponding formation of any other locality as far as we know. In the second place, the *Fusulina* limestone which is always found at the lower or middle part of the coal series in other regions of northern China seems to be wanting in Hsi-Shan. Finally, the iron-ore bearing beds at the base of the coal series is not so often seen here; only at Ch'an-Fan (禪房) and Wang-Ping-Kou there are small outcrops of limonitic ore and in the north of Ta-Hui-Ch'ang ferruginous shales and clay are present. As numerous fossils have been collected in Yang-Chia-T'un this formation is therefore, named after the place.

TRANSITION FORM PALAEOZOIC TO MESOZOIC**PERMO-TRIASSIC.****Hung-Miao-Ling (紅廟嶺) Sandstone.**

General Statement.—From Paleozoic to Mesozoic the stratigraphic history of Hsi-Shan is represented by a transitional formation of doubtful age, which is a quartzose sandstone, commonly yellowish white in colour and conformable in strike and dip with the overlying and underlying sequence. Its total thickness is about 350 m. at Hung-Miao-Ling; 150 m. at Yang-Chia-T'un; and 75 m. at Hsing-Yuan (杏園) west of Wan-Fo-T'an.

Occurrences.—Around Kiu-Lung-Shan (九龍山) and Pei-Ling synclines this sandstone is exposed in long and more or less continuous belts. In other words, wherever the two coal series, the Carboniferous and the Jurassic occur, it is constantly found to be intercalated between them. But in most cases, it is separated from the latter formation by a diabase intrusion. The mountain ridge of Hung-Miao-Ling and Nin-Hsin-To (PLIB) is formed of this sandstone. Its characteristic feature can be even recognised from Mên-T'ou-Kou railway station when looking in the southwest direction. It lies between the Yang-Chia-T'un series and a Jurassic formation which we shall call Mên-Tou-Kou series. Here, the sandstone is made up of medium-grained quartz and red ferruginous and quartzose cements. Some parts of it are deeply weathered and therefore soft.

In Yang-Chia-T'un, the same formation is also very well exposed between the Carboniferous series and a diabase intrusion (see PLXV). This is composed of coarse, white quartz grains cemented by brownish ferruginous material. Beneath the sandstone is a reddish clay of about one to two feet thick.

Along the southern bank of Hun-Ho (渾河) from Lêng-Ko-Chuang (冷各莊) to Shai-Shu-Fêng (晒樹坎) north of Kiu-Lung-Shan, the quartz grains of this sandstone are much coarser than those of the above named places and the rock contains less cement. It is underlaid by thin bands of red shales which may be easily mistaken for the red shale of Kiu-Lung-Shan series that will be described later.

In the syncline of Pei-Ling, the diabase is absent. Its apparent concordant contact with the underlying and overlying formations can be clearly observed. On the northeast of Wan-Fo-T'an and west of T'o-Li (坨里), there are two large occurrences of the quartzose sandstone forming the mountain of Nan-Ta-Chai (南大寨) and Pei-Ta-Chai (北大寨). There it appears as faulted blocks striking S and N dipping toward W at an average angle of 30° . The rock is quite compact and scarlet coloured. At first sight it was impossible to correlate it with any known formation in the region under study. After repeated researches it was proved to be composed of fine quartz grains with much red ferruginous cements. In its lower horizons the grains are comparatively coarse. At Mei-Ling it lies conformably on the Yang-Chia-T'un coal series. On the way from Mei-Ling to Pei-Chê-Ying (北車營) the sandstone is traversed by some pegmatite veins and locally exhibits schistose structure. Evidently this is the same sandstone formation that has been already discussed. It is here simply more compact, reddish and finer grained in the upper part. Although its exposure seems particularly broad owing to the gentle dip of the beds, its real thickness is only about 350 m.

As far as has been observed in the localities above mentioned the sandstone is either overlaid by a Jurassic series or is separated from it by an intrusive diabase sheet. On the far northeastern part of Hsi-Shan however the quartzose sandstone is directly succeeded above by a series of violet and green shales and sandstones which commonly rests on the Jurassic coal bearing formation in most localities of Hsi-Shan. We attribute this deviation to the thinning out of the Jurassic coal bearing formation and overlapping of the violet and green series.

Age and Correlation—No fossils have been found in this rock, so its age is uncertain. We assign it to the Permo—Triassic age because it occupies the transitional position from the Carboniferous to the Jurassic both determined by characteristic plant fossils although it may be either a part of either. In the field, it forms an easily recognisable zone very useful for distinguishing the two coal-bearing series.