North Ta-tung Coal Field

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I. Introduction

A. LOCATION AND ACCESSIBILITY

The Ta-tung coal field is a general name of a coal-producing province lying southwest of the Ta-tung prefectural castle on the Pei-ching to Pao-tou railroad line. The coal field extends over Ta-tung, Tso-yun, Huai-jen, Shou-hsien, Ping-lu, and Yu-yu-hsien for about 150 km from northeast to southwest, and it varies from 17 km to 30 km in breadth from northwest to southeast. The total area is about 3,000 sq. km (See Fig. 1).

A branch line of the Pei-ching to Pao-tou line runs 20 km from the Ta-tung station to Kou-chuan in the northeastern part of the coal field; private tracks were laid for 4 km to Yung-ting-chuang, for 3 km to Mei-yu-kou, for 6 km to Pao-chin, and for 9 km to the Pai-tung mine. These lines still existed in 1945. The Ta-tung coal field lies to the west of Shuo-hsien on the North Ta-tung—Pu-chou line which extends from Ta-tung to Tai-yuan in Shansi Province. Coal mining is done by primitive methods in the western parts of Huai-jen, Tai-yueh-chen and Shou-hsien regions, and in the valleys which are located within an area tending from Ta-tung to Yun-kang to Tso-yun district of the coal field.

B. HISTORY OF THE INVESTIGATION OF THE COAL FIELD

1. *Investigation before the Mapping Survey*

Prior to 1937, the Tsin-pei Mining Bureau and the Pao-chin Co. operated mines at Yung-ting-chuang, Mei-yu-kou, and Pao-chin in the northeastern part of this coal field. In February 1938, the South Manchuria Railway Company was entrusted with the management of these mines, and the subsequent coal production increased. In January 1940, the Ta-tung Coal Mine Company was established, and the management was transferred from the South Manchuria Railway Co. to this new company. The Ta-tung Coal Mine Co. produced coal from the shafts at Yung-ting-chuang, Yu-feng (formerly Mei-yu-kou) and Pao-chin, and furthermore, opened new pits at Tung-chia-liang, Pai-tu-yao, Pai-tung, Pao-tsang and Showa (Chao-ho, in Chinese). The mines prospered to such an extent that the annual output amounted to 2,500,000 metric tons.

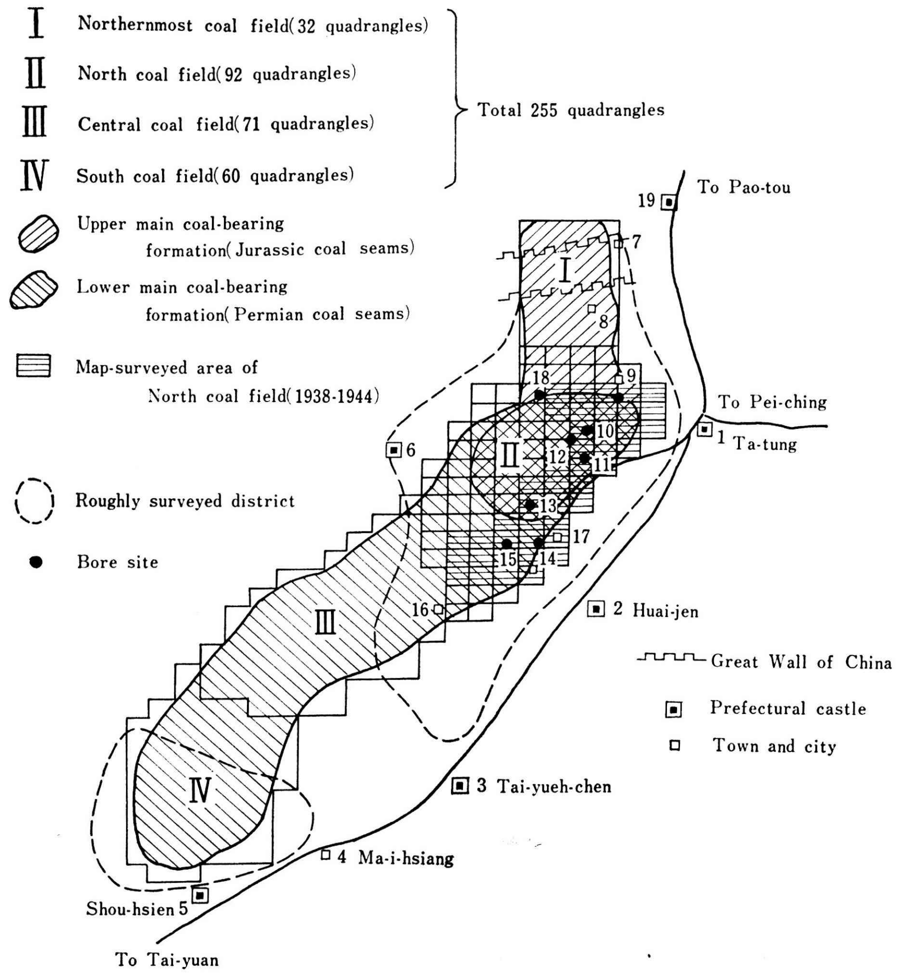


Fig. 1. Quadrangles of the Ta-tung coal field under survey (1938–1944).

1. Ta-tung
2. Huai-jen
3. Tai-yueh-chen
4. Ma-i-hsiang
5. Shou-hsien
6. Tso-yun
7. Kao-chia-yao
8. Chen-ho-pao
● 9. Yun-kang
● 10. Nan-hsin-chuang
● 11. Tiao-wu-tsui
● 12. Pai-tu-yao
● 13. Chang-liu-shui
● 14. Yao-tzu-tou
15. Wang-pien-chuang
16. Wu-chia-yao
17. E-mao-kou
● 18. Kao-shan-chen
19. Feng-chen

This coal field was first surveyed in 1919 by Sanno KADOKURA, a Japanese geologist, who pointed out its importance. Among the Chinese geologists, Wang Chu-chuan surveyed the entire coal field and reported the outline in 1921.

In 1936, Toshio TAKEYAMA, geologist of the South Manchuria Railway Co., surveyed the Kou-chuan district which is located in the northeastern part of this coal field. He discovered a kaolin deposit of superior quality in the Permian Coal Measure. In December 1937, Fusao UEDA, Hikoji MORITA, and Hajime YOSHIZAWA, geologists of the South Manchuria Railway Co., investigated the geology of the working areas of the Tsin-pei Mining Bureau and the Pao-chin Co. in the northeastern part of this coal field.

2. *Mapping Survey*

The detailed geological survey plan; for the overall coal field was established by the South Manchuria Railway Company in 1938, and the field party, the chief of which was Hikoji MORITA, was organized under the direction of Takao SAKAMOTO. According to this survey plan, the coal field was divided into 240 quadrangles each of which had an area of 12 sq. km.[1] These quadrangles were delimited by a set of parallel lines 4 km apart which estended from east to west and another set of parallel lines 3 km apart which extended from north to south. A detailed geological survey was scheduled to be performed in succession for every quadrangle. The field party was divided into the geology team, the surveying team and boring team. The surveying team made the topographic maps on a 1:10,000. After the actual surveying the geology team used these topographic maps for their general geological survey of which the primary purpose was the gathering of fundamental data for economic exploitation. This was done by emphasizing the modes of occurrence of the coal seams. Then, the boring team decided the bore sites and examined the boring cores. By 1940, the detailed survey of the following 13 quadrangles (156 sq. km) was completed, covering an area extending from Kou-chuan westward to Chang-liu-shui.[2]

1.	Yung-ting-chuang sheet	Hikoji MORITA
2.	Pai-tung-tsun sheet	Hikoji MORITA and Toshiji TAKAHASHI
3.	Yin-tang-kou sheet	Michisu MUKAI
4.	Ssu-lao-kou	Yoshio ONUKI
5.	Yen-yai sheet	Yoshio ONUKI
6.	Wei-chia-kou sheet	Yoshio ONUKI
7.	Lao-yao-kou sheet	Yoshio ONUKI
8.	Chang-liu-shui sheet	Yoshio ONUKI
9.	Mei-yu-kou sheet	Yoshio ONUKI
10.	Yu-feng mine sheet	Hikoji MORITA and Toshiji TAKAHASHI
11.	Pai-tu-yao sheet	Hikoji MORITA and Michisu MUKAI
12.	Pao-chin sheet	Chang LI-HSU
13.	Nan-hsin-chuang sheet	Chang LI-HSU

1) Up to 1943, the coal field was regarded as being 120 km long from NW to SE, 17–30 km long in breadth, and 2,400 sq. km in area. After investigations by H. Morita and C. Hasegawa in 1943–1944, the northern limit was widened and the area was greatly increased; total 250 quadrangles, 3,000 sq. km.

2) The stratigraphical results were compiled in "The Preliminary report of the Ta-tung Coal Field geologic survey party," and the outline was introduced by Chang Li-hsu in *Jour. Geol. Soc. Jap.*, vol. 48, no. 575, 147–150, 1941.

The results were published under the title of "The explanatory text to the Northern Ta-tung Coal Field geologic maps by the Industry Department, United Autonomies of Mongolia." The map survey investigators were Kenichi OKI, Kenkichi MASUBUCHI, Toshiji TAKAHASHI, Sakujiro KOIDE, Michisu MUKAI, Chang LI-HSU, and I, Yoshio ONUKI, and Hikoji MORITA who was chief of the party. I joined Hikoji MORITA in the Mongolian Resources Investigation Party, which was organized by the Mongolian government in 1939, and we surveyed the

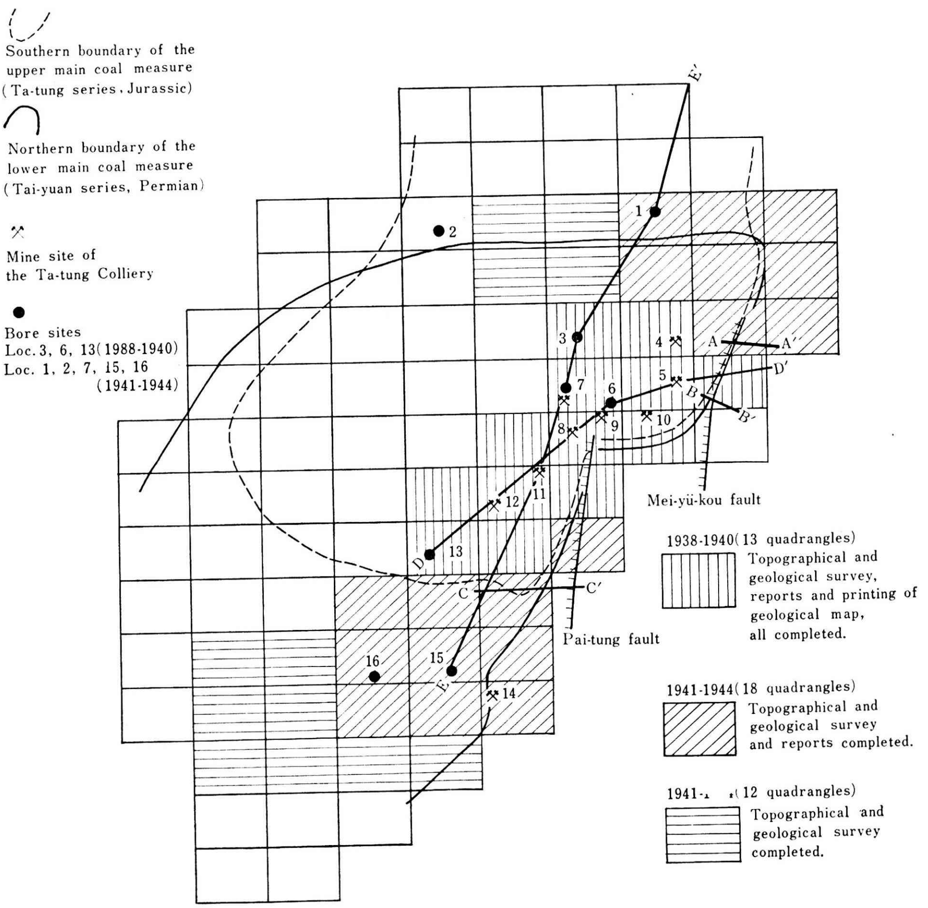


Fig. 2. Survey plan for making geological explanatory sheets (scale 1: 10,000) in north coal field.

● 1. Yun-kang	● 7. Pai-tu-yao Mine	● 13. Chang-liu-shui
● 2. Kao-shan-chen	8. Pai-tung Mine	14. Shao-ho Mine
● 3. Nan-hsin-chuang	9. Tung-chia-liang Mine	● 15. Yao-tzu-tou
4. Pao-chin Mine	10. Yung-ting-chuang Mine	● 16. Wang-pien-chuang
5. Yu-feng Mine	11. Pao-tsang Mine	
● 6. Tiao-wo-tsui	12. Yen-yai	

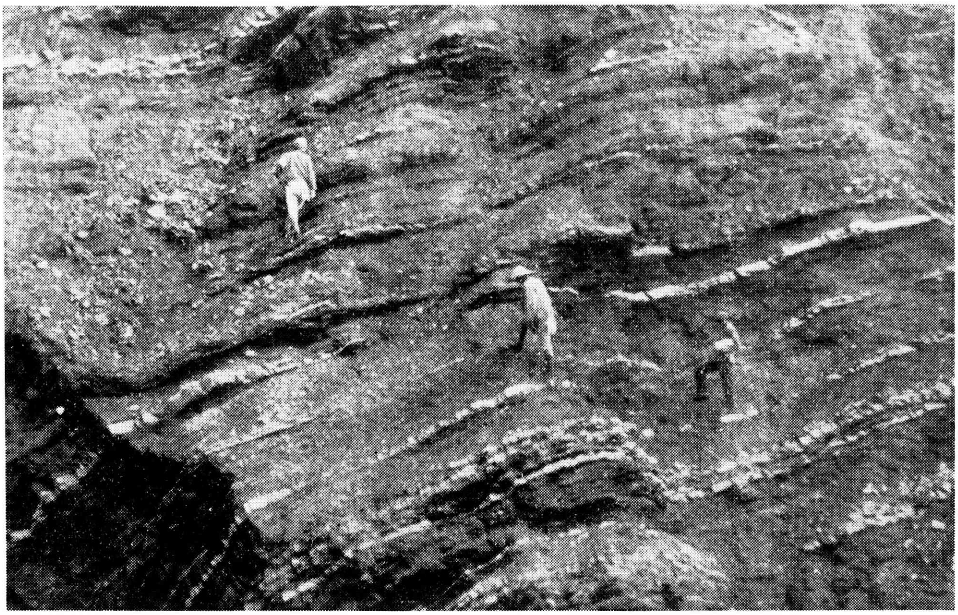
		(13) Nan-hsin-chuang B : 2.65 E : 5.88 d: 7.87 C: 0.73 E_1: 2.36 f : 7.20 D: 0.75 F : 3.58 D_1:1.20 G : 0.10	(12) Pao-chin B : 2.50 F : 1.20 d: 7.00 C: 1.00 G: 2.20 f : 5.00 D: 1.20 E : 4.00	
		(11) Pai-tu-yao B : 0.85 F : 1.20 b: 1.85 C: 1.10 G: 1.20 d: 15.15 D: 1.40 f : 3.80 E : 5.00	(10) Yu-feng coal mine A: 0.70 E : 3.50 b: 0.45 B : 1.60 F : 1.20 c : 0.85 C: 1.50 G: 1.20 d: 17.10 D: 1.80 e : 0.45 g : 3.80	(9) Mei-yu-kou B : 2.00 F : 1.30 d: 7.00 C: 1.50 G: 2.00 f : 3.50 D: 0.45 E : 2.80
	(3) Yin-tang-kou B : 1.00 F : 1.50 d: 15.00 C: 1.50 F_1: 1.50 f : 4.50 D: 1.00 G : 1.40 E : 5.00	(2) Pai-tung-tsun B : 0.85 F : 1.20 d: 10.00 C: 1.40 F_1: 0.55 e : 1.90 D: 1.80 G : 1.20 f : 3.80 E : 5.50	(1) Yung-ting-chuang B : 0.85 F : 1.20 b: 0.45 B_1: 0.50 F_1 : 0.55 c : 0.85 C : 1.40 G : 1.20 d:17.10 D : 1.40 G_1: 0.65 e : 0.45 E : 3.85 f : 3.80	
(6) Wei-chia-kou B : 0.80 F : 3.50 d: 15.00 C: 1.40 G: 2.00 f : 5.70 D: 0.50 E : 3.00	(5) Yen-yai B : 1.00 F : 2.00 d: 17.00 C: 1.60 F_1: 2.20 f : 6.00 D: 0.70 G : 1.70 E : 5.00	(4) Ssu-lao-kou B: 1.00 F : 3.00 d: 10.00 C: 1.60 G: 1.70 f : 4.50 E: 0.70 E: 4.00		
(8) Chang-liu-shui B : 0.80 F : 3.00 d: 15.00 C: 1.20 G: 3.00 f : 5.70 D: 0.50 E : 2.00	(7) Lao-yao-kou C: 1.40 G: 2.40 b: 0.60 D: 0.50 d: 18.00 E : 2.50 e : 1.50 F : 2.50 f : 8.00			

Coal seams of the Ta-tung series, Jurassic
A, B......G

Coal seams of the Shan-hsi series, Permian
a Upper No. 0 bed
b Upper No. 1 bed
c Upper No. 2 bed

Coal seams of the Tai-yuan series, Permian
d 20 meter bed
e Lower No. 1 bed
f 5 meter bed
g Lower No. 2 bed

Fig. 3. Thickness of coal seams (m) in each quadrangle of the north ta-tung coal field.



Outcrop of Tai-yuan "20m seam" at Chin-shan-ssu, Ta-tung coal field. (black: coal, white:kaolinite. The person in the middle is the writer.).

Wu-chia-yao district in the central part of the Shuo-hsien region in the southern coal field.

In 1941, the investigation work was assumed by the Investigation Bureau of the North China Development Co. and the survey was continued by Hikoji MORITA, chief of the party, and others under the direction of Fujio HOMMA and Nobuo YAMANOUCHI. From 1941 to 1944, 12 sheets of maps for the area extending between Yun-kang-chen and Kao-shan-chen along the Shih-li-ho (144 sq. km), and 18 sheets of maps for the region extending from E-mao-kou in Huai-jen to Wang-pien-chuang (216 sq. km), were completed, and also the area extending from the north of the Shih-li-ho to the west of Feng-chen was surveyed in order to decide the northern limit of this coal field. The survey from 1941 to 1944 was chiefly directed by Hikoji MORITA with Chozaburo HASEGAWA and Kiyoto KIYOHARA assisting; I examined some of the boring bores.

This survey work is summarized as follows (See Figs. 1, 2, and 3):

1938–1940

(a) Mapping survey of the Northern coal field between Kou-chuan and Chang-liu-shui, 13 sheets, 156 sq. km (See Fig. 3).

(b) Boring at three sites, i.e., Chang-liu-shui, Tiao-wo-tsui, and Nan-hsin-chuang.

(c) Rough survey of Wu-chia-yao district in the central coal field.

(d) Rough survey of the western region of Shuo-hsien in the southern coal field.

1941–1944

(a) Mapping survey of the area along the Shih-li-ho between Yun-kang-chen and Kao-shan-chen, 12 sheets, 144 sq. km.

(b) Mapping survey of the E-mao-kou—Wang-pien-chuang district in Huai-jen-hsien in the northern coal field, 18 sheets 216 sq. km.

(c) Rough survey of the western region of Feng-chen in the northernmost coal field.

(d) Boring at 5 sites, i.e., Yu-kang-chen, Kao-shan-chen, Pai-tu-yao, Yao-tzu-tou, and Wang-pien-chuang.

Table 1. Stratigraphic Order of Ta-tung Coal Field*

Period		Formation	Character	Thickness (m)
Quaternary		Alluvial formation	Loess, etc.	10–40
		Diluvial formation		2–80
			Conglomerate	2–5
			Basalt	40–100
Tertiary?		Tso-yun series	Red clay	150
Cretaceous?		Hun-yuan series	Andesitic agglomerate	5–30
		Nan-hsin series	Red shale and sandstone	25–160
Jurassic		Yun-kang series	White sandstone and conglomerate	30–100
		Ta-tung series	Upper main coal measure	214–320
Triassic (Uppermost)				
Permian	Upper	Huai-jen series	Red-colored rocks	0–340
	Middle	Shan-hsi series	Sandstone and shale	0–170
	Lower	Tai-yuan series	Lower main coal measure	0–130
Carboniferous	Middle	Ping-ting series	Shale and sandstone	0–45
Ordovician	Middle	Ordovician formation	Limestone and dolomite	0–300
	Lower			
Cambrian	Upper	Cambrian formation	Oolitic and worm-like limestone	35–450
	Middle			
	Lower	Man-tou series	Red shale and sandstone	0–170
Archeozoic		Sang-kan gneiss		

* This table is modified after Hikoji Morita. ------- Unconformity.

From 1938 to 1944, 43 sheets of maps totaling 516 sq. km were completed, and bores were made at 8 sites. Of the 43 sheets, printing of 13 with their explanatory texts were completed. Others were forwarded for printing or were being prepared for printing at the end of World War II so the report, unfortunately, was not completed. Moreover, Chozaburo HASEGAWA had summarized maps of 1:10,000 scale and made a geologic map of 1:50,000 scale, but this map was not printed.

II. Geology (I) Pre-Upper Paleozoic Era

A. General Remarks

Within this coal field and its marginal region, Sang-kan gneisses, Lower Paleozoic formations, Upper Paleozoic formations, Mesozoic formations, Tertiary complexes and Quaternary complexes were found. The nomenclature for these formations is shown in Table 1. The stratigraphic order and geologic structure of this coal field present an important key to the understanding of the general feature of the geologic order and of the crustal disturbance in North China.

B. Sang-kan Gneiss

This is the oldest rock series found in this coal field and is composed of granitic gneiss and schists of various kinds distributed on the eastern and the northern margin of this coal field.

C. Man-tou Series

This series consists of complex red-colored shale and sandstone belonging to the lower Cambrian period. It has conglomerate at the base, and it overlines the San-kan gneiss to form an angular unconformity. This series is distributed widely along the eastern margin of the coal field, and from a high point its distribution can be seen at a glance because the red-colored rocks are well exposed. This series has a zone containing pseudomorphs of salt discovered by Fusao UEDA in 1937 in the vicinity of Yao-tsu-fang on the southern foot of Chi-feng-shan (UEDA, 1939). The sandstone of this series sometimes contains ripple marks, which suggest the series was deposited in a wide lagoonal area at high temperatures and in a dry climate.

D. Middle and Upper Cambrian Formation

This formation consists of oolitic and worm-like limestone which occurs in zones in the eastern margin of the coal field, and forms the high and steep Kou-chuan mountains. It occurs with the dolomite and the limestone of the Ordovician period which will be described later. This series differs strikingly from the Man-tou series in its resistance to erosion, whereas the Man-tou series is brittle and weak and is apt to erode easily. When the Man-tou series occurs on a slope, the limestone of this series resting upon it forms conspicuous cliffs.

A fossil zone yielding *Ptychoparia orientalis* RESSER and ENDO, occurs in the upper horizon of the middle part of this series, and the upper part yield *Tsinania canens* (WALCOTT), *Prosaukia briioformis* ENDO, and *Eoorthis linnarssoni* WALCOTT.

This formation has a thickness of more than 300 m at E-mao-kou and the Kuo-chia-kou map sheet area west of Huai-jen, but it is approximately 50 m thick in the Ching-tzu-yao map sheet area along the Shih-li-ho west of Ta-tung. This may be due to erosion accompanied by crustal movement, as will be mentioned later. Much limestone of this formation is suitable for cement and iron manufacturing. The Mongolia Cement Co. is quarrying the limestone north of Ping-wang for the manufacture of cement.

E. LOWER AND MIDDLE ORDOVICIAN FORMATION

This formation is composed of dolomite and limestone, which contains *Collenia grandise* ENDO at the base. The limestone also yields *Maclurea* and primitive cephalopoda. This formation is 300 m thick in the southern part of the coal field and is found with Cambrian limestone, but it completely disappears in the northern part of the field as the result of erosion.

III. Geology (II) Lower Coal Measure

A. PING-TING SERIES

This name was recently given to the lower part of the old Pen-chi series. I divided the Pen-chi series in two; the lower part was renamed the Ping-ting series and the upper part the Ching-hsin series as the result of investigation of the Ching-hsing coal field. The Ping-ting series is well developed but the Ching-hsing series is absent in the North Ta-tung coal field. This series is composed mainly of shale and sandstone in alternation and intercalated with thin layer of limestone (Kou-chuan limestone); it covers the Ordovician formation unconformably, and the "G"-bed (a marker bed) of aluminous shale occurs at the base. A relation of unconformable overlapping between this series and the Lower Paleozoic formation changes gradually from south to north. Stratigraphically, this series overlies unconformably the Middle Ordovician formation in the south, and overlies the Cambrian formation in the north. The lowest stratum of this series outcrops in the south, and as one goes to the north, the strata of the upper horizons, resting upon the bed rock appear successively. It is thus clear that this series was deposited upon the Cambro-Ordovician formation from south to north in the state of overlap. This series is intercalated with limestone beds of 2.5 m to 4 m in thickness (Kou-chuan limestone) in the horizon from 12 m to 28 m above the base, and sometimes contains thin layers of coal seams which are unworkable. Within the surveyed area the Ping-ting series is 45 m thick in the south, and gets thinner toward the north, and disappears completely. This is due not only to deposition in the state of overlap, but also to erosion before the deposition of the Tai-yuan series, which will be described later.

The following fossils are known to be from the Kou-chuan limestone:

Ozawainella angulata (COLANI)
Fusiella typica LEE et CHEN
Fusulinella bocki MOLLER
Fusulinella Kon'noi (OZAWA)
Bradyina cf. *rothula* (EICHWALD)
Bradyina cf. *nautiliformis* MÖLLER
Bradyina sp.
Tetrataxis parviconica LEE et CHEN
Tetrataxis minima LEE et CHEN
Textularia cf. *exima* EICHWALD
Arachaenastraea manchurica YABE et HAYASAKA
Syringopora reticulata GOLDFUSS
Chaetetes penchiensis CHU
Spirifer cf. *nikitini* TSCHERNYSCHEW
Productus sp.

Among them, *Chaetetes* shows a characteristic mode of occurrence, and is yielded abundantly from masses of reefs. These masses are larger than a man's fist and are scattered like pebbles in the vicinity of the limestone which has been decomposed by weathering. It is known that this fossil occurs in the Nagaiwa series in the Kitakami district, Japan. There may be some stratigraphic relation between the two. This series is regarded as the same horizon as the Huang-lung limestone in Central and South China, and as the Pen-chi series[3] in Manchuria from the study of fusulinids, corals and brachiopods, etc.

B. TAI-YUAN SERIES

This series is mainly composed of shale and sandstone in alternation; the basal conglomerate which varies from 4 to 10 m in thickness, overlies the Ping-ting series with a disconformity in most places, but in the northern portion it unconformably overlies the Cambro-Ordovician formation. This series is intercalated with coal seams of the 20 m bed and the 5 m bed, but involves no limestone within the map survey area. The series includes two layers of marly limestone or calcareous shale which yields fossils of fusulinids, brachiopods and bivalves in the south area of this coal field and the Huan-yuan coal field. The states of the complex and the coal seams of this series are analogous to the Ta-tung and the Hun-yuan coal fields; the coal seams alternate with partings of kaolin; the maximum thickness amounts to 34 m. One of the seams is called "the 20 m bed", of which the coal is 8 to 10 m and the kaolin is about 12 m in thickness. This series is called the Lower main coal measure. According to the boring logs, this series is not developed northern area of the Ta-tung to Yun-kang to Tso-yun road. The Ta-tung series, which is the Upper main coal measure, extends northward to the west of Feng-

3) In Manchuria transgression happened earlier, and the lower limit is supposed to be older.

chen, so the area where both the Ta-tung series and this series is developed, is confined to the area west of Huai-jen to the Yun-kang—Tsu-yun road (See Fig. 1, and 6).

I collected the following fossils from the area between Kou-chuan and Chin-shan-ssu as well as from the map sheet area of Ssu-lao-kou and Lao-yao-kou:

1. *Tingia carbonica* (SCHENK) HALLE
2. *Tingia elegans* KON'NO
3. *Plagiozamites* cf. *oblongifolius* HALLE
4. *Lepidodendron oculus-felis* (ABBADO) ZEILLER
5. *Stigmaria ficoides* BRONGNIART
6. *Annularia stellata* (SCHLOTHEIM) WOODWARD
7. *Calamites cisti* BRONGNIART
8. *Calamites Suckowii* BRONGNIART
9. *Sphenophyllum Thonii* MAHR
10. *Sphenophyllum emarginatum* BRONGNIART
11. *Sphenophyllum verticillatum* (SCHLOTHEIM) BRONGNIART
12. *Pecopteris hirta* HALLE
13. *Pecopteris candolleana* BRONGNIART
14. *Pecopteris orientalis* (SCHENK) POTONIÉ
15. *Pecopteris arborescense* (SCHLOTHEIM)
16. *Sphenopteris tenuis* SCHENK
17. *Sphenopteris* sp.
18. *Emplectopteris triangularis* HALLE
19. *Cordaites principalis* GEINITZ
20. *Cordaianthus* ? sp.

C. SHAN-HSI SERIES

This series consists of sandstone and shale in alternation, and contains conglomerate at the base which has a maximum thickness of 20 m. This series appears as if it covers the Tai-yuan series with a disconformity. However, the outcrops of Tiao-wo-tsui, Yao-tzu-tou, and Chin-shan-ssu, and the bore logs of Tao-yao chu and Chang-liu-shui, revealed a shale bed, varying from 5 to 10 m in thickness, which rests upon the uppermost coal seam of the Tai-yuan series (20 m bed). On the other hand the outcrop of Lao-yao-kou and of the valley south of Kou-chuan, shale and the upper part of the coal seam are eroded so that the basal conglomerate of the Shan-hsi series directly overlies this coal seam (See Figs. 4 and 6).

The coal seams of this series are developed best in the map-sheet area of Lao-yao-kou, and these are named in order beginning with the youngest seam. They are the Upper No. 0 bed, the Upper No. 1 bed, and the Upper No. 2 bed,[4] but

4) At the boring of Tao-wo-chu No. 2, the coal seams were called the Upper No. 1 bed and the Upper No. 2 bed, but a new coal seam was discovered in the upper horizon during exploration of the Lao-yao-kou map sheet area, 0 bed was eroded out at the bore site of No. 2.

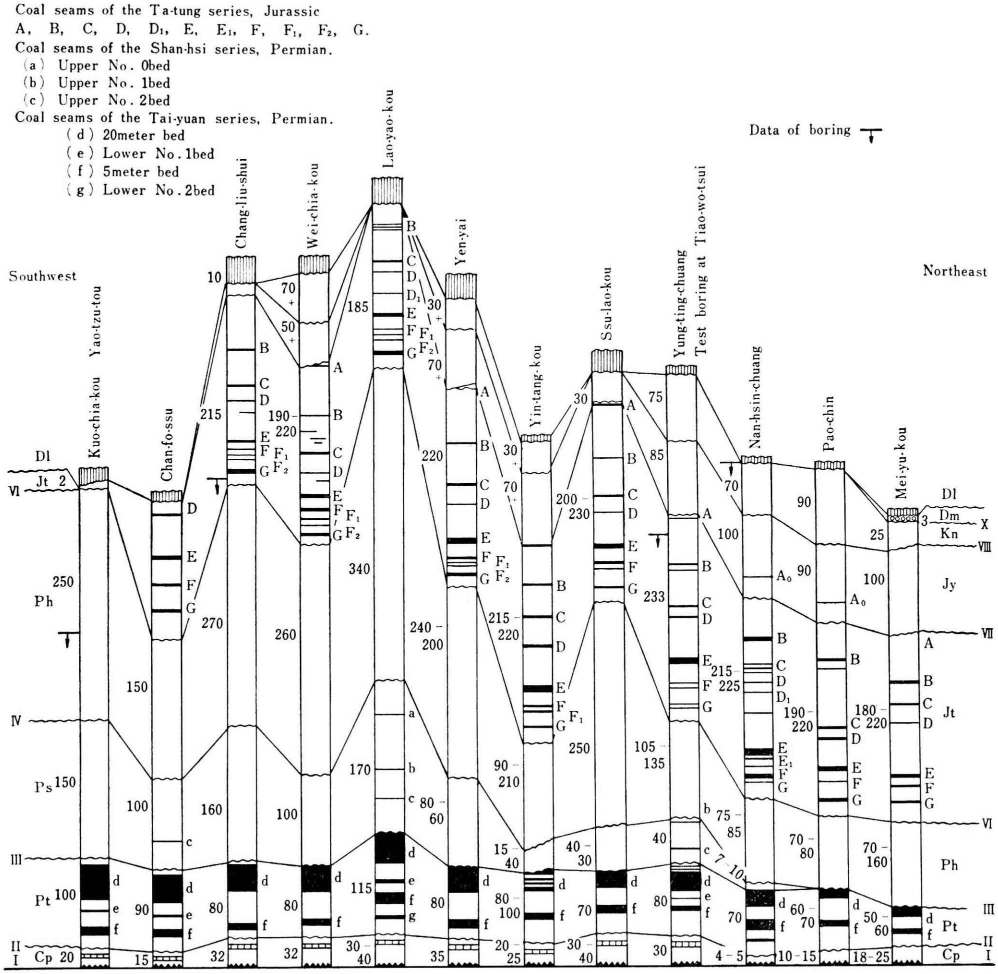
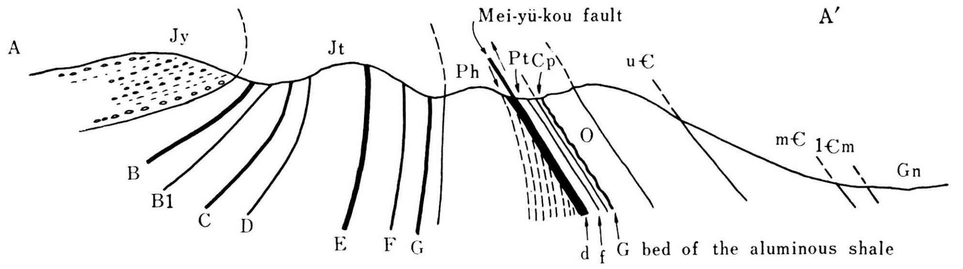


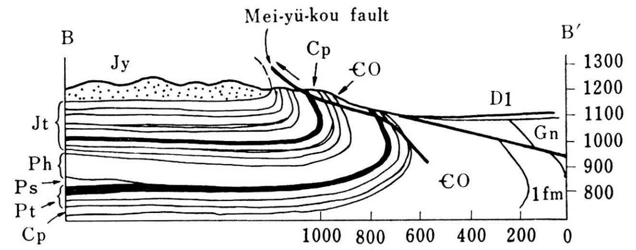
Fig. 4. Columnar-sections of the North Ta-tung coal field.

Dl: Quaternary, Loess
Dm: Quaternary, Mei-yu-kou Conglomerate
...... X (IX)...... (Yen-shan movement)
Kn: Cretaceous, Nan-hsin series
...... VIII ...... (Feng-chen movement)
Jy: Jurassic, Yun-kang series
...... VII ...... (Pao-chin movement)
Jt: Jurassic, Ta-tung series (Upper main coal measure)
...... VI (V) ...... (Shan-tung movement)
Ph: Permian, Huai-jen series
...... IV ...... (Tsin-pei movement)
Ps: Permian, Shan-hsi series
...... III ...... (Chiao-tzo movement)
Pt: Permian, Tai-yuan series (Lower main coal measure)
...... II ...... (Tzu-hsien movement)
Cp: Carboniferous, Ping-ting series
...... I ...... (Tai-hang and Kai-luan movements)
CO: Cambro-Ordovician formations
Sequence determined by the test boring

A–A′: Section A–A′ is in the Lung-erh-kou map area which is bounded on the south by the Mei-yu-kou map area. The section was made from the photograph (taken by the author in 1939) of the north cliff of Lung-erh-kou as viewed from a point located on the western part of the boundary line which separates the above two map areas.



B–B′: E–W section in the Geological Map of Mei-yu-kou (After the author's original)



C–C′: E–W section in the Geological Map of Kuo-chia-kou

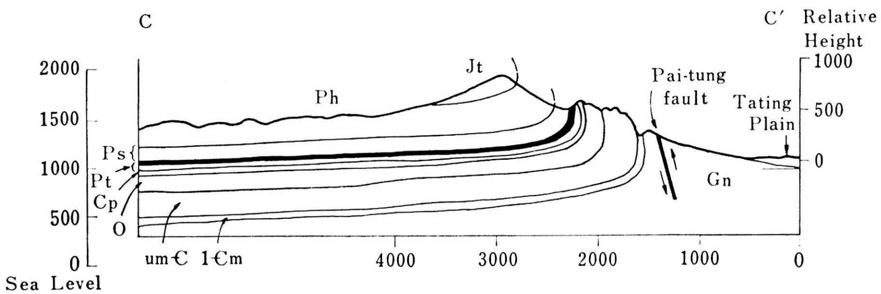


Fig. 5. Cross sections of the North Ta-tung coal field (1).

Dl : Diluvium or Alluvium (loess, etc.)
Jy : Jurassic, Yun-kang series
Jt : Jurassic, Ta-tung series
Ph : Upper Permian, Huai-jen series
Ps : Middle Permian, Shan-hsi series
Pt : Lower Permian, Tai-yuan series
Cp : Middle Carboniferous, Ping-ting series

O : Ordovician (Lower to Middle)
CO : Cambro-Ordovician
uC : Upper Cambrian
mC : Middle Cambrian
lCm: Lower Cambrian, Man-tou series
Gn : Sang-kan gneisses

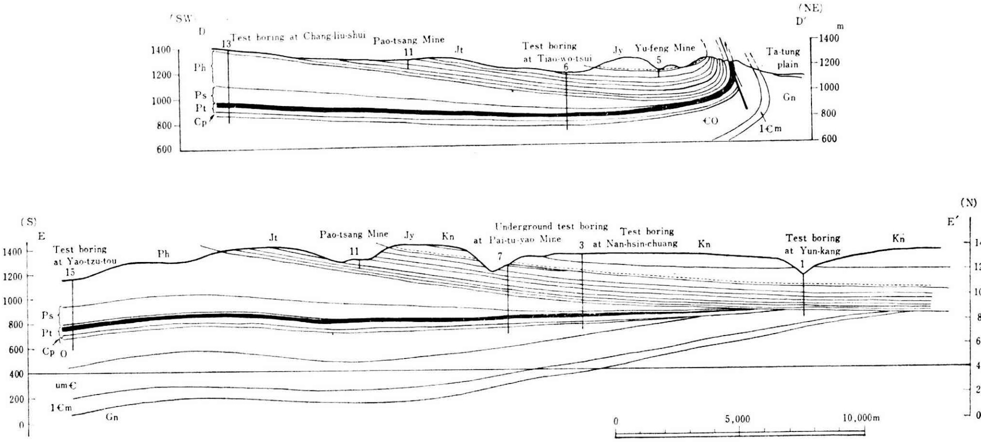


Fig. 6. Cross sections of the North Ta-tung coal field(2) (Legend: same as Fig. 5).

1. Test boring at Yun-kang
3. Test boring at Nan-hsin-chuang
5. Yu-feng Mine
6. Test boring at Tiao-wo-tsui
7. Underground test boring at Pai-tu-yao Mine
11. Pao-tsang Mine
13. Test boring at Chang-liu-shui
15. Test boring at Yao-tzu-tou

these are generally thin and less than 0.8 m in thickness. These change to thin layers of coal seams, to coaly shale, or they thin out completely in the area of Kuo-chia-kou map sheet, and in the bore of Chan-liu-shui.

A remarkable unconformity is seen between this Shan-hsi series and the Huai-jen series, which overlies the former. The Shan-hsi is about 170 m thick and intercalates the Upper 0 bed, the Upper No. 1 bed, and the Upper No. 2 bed in the area of Lao-yao-kou map sheet. The bore log at Tiao-wo-tsui shows that the thickness is reduced to about 40 m and that the Upper No. 0 bed has already disappeared. The bore log at Nan-hsin-chuang shows that the thickness is reduced to only several meters due to erosion, and finally in the area along the Yun-kang—Tso-yun road (boring at Yun-kang-chen and Kao-shan-chen) this series is completely eroded away. Therefore at this point the thickness of this series which has been eroded away is greater than 170 m.

I collected the following plant fossils from the Shan-hsi series while doing the exploration work for the Ssu-lao-kou and Lao-yao-kou map sheets:

1. *Plagiozamite* sp.
2. *Lepidodendron oculus-felis* (ABBADO) ZEILLER
3. *Stigmaria ficoides* BRONGNIART
4. *Lobatannularia* sp.
5. *Calamites cisti* BRONGNIART

6. *Calamites Suckowi* BRONGNIART
7. *Sphenophyllus Thonii* MAHR
8. *Sphenophyllum Thonii* var. *minor* STERZEL
9. *Protoblechnum* sp.
10. *Sphenopteris Gothani* HALLE
11. *Emplectopteris triangularis* HALLE
12. *Taeniopteris* sp.
13. *Cordaites principalis* GEINITZ
14. *Cordaites Schenkii* HALLE
15. *Pterophyllum nilssonioides* KAWASAKI

D. HUAI-JEN SERIES

This series, up to 1940, was called the "Shuang-chuan series" in the explanatory text of geologic map. It is a red-colored rock complex of shale, sandstone and conglomerate. A thick basal conglomerate occurs in the base of this series which covers the Shan-hsi series unconformably. The thickness of the Huai-jen series varies according to the relation of the unconformity to the lower complexes and the Ta-tung series in the upper horizon. The thickness is about 250 m in the map sheet area of Wang-pien-chuang and Yao-tzu-tou, and 150 to 340 m in the map sheet area of Lao-yao-kou, Chan-fo-ssu, and 270 m at the bore site of Chang-liu-shui, and 105 m or so at the bore site of Tiao-wo-tsui and 75 m at the bore site of Nan-hsin-chuang. The Huai-jen series does not exist in the vicinity of the Yun-kang to Tso-yun road. If this series is traced from south to north, the lower complexes which occur in the south are not found in the north, and it is suggested that the sedimentation of this series was started in the south, and a rather long time was needed before deposition occurred in the northern extremity (See Fig. 4).

No fossils were found in this series up to 1940, and the series was correlated with the Shuang-chuan series on the basis of the rock facies only. But Chozaburo HASEGAWA, geologist of the North China Development Co., discovered *Lepidodendron* in the northern area of Wang-pien-chuang within the map-sheet area of Wang-pien-chuang upstream from E-mao-kou in Huai-jen-hsien in 1942. There is a first fossil zone yielding *Lepidodendron* and *stigmaria* etc. abundantly in a horizon about 30 m below the base of the Ta-tung series, i.e. in the upper horizon of the Huai-jen series. A second zone which mainly yields Sphenophyllum and Pecopteris, occurs in a horizon 17 m below the zone mentioned above. A third Cordaites zone lies 70 m below it.

Hikoji MORITA identified the following fossils from the Huai-jen series:

1. *Tingia partita* HALLE
2. *Lepidodendron oculus-felis* (ABBADO) ZEILLER
3. *Lepidodendron Gaudryi* RENAULT
4. *Lepidodendron* sp.
5. *Sigillaria* sp.
6. *Stigmaria ficoides* (STERNBERG) BRONGNIART

7. *Annularia gracilescens* HALLE
8. *Annularia mucronata* SCHENK
9. *Calamites Suckowii* BRONGNIART
10. *Sphenophyllum Thonii* MAHR
11. *Sphenophyllum Thonii* var. *minor* STERZEL
12. *Sphenophyllum sino-coreanum* YABE
13. *Sphenophyllum verticillatum* (SCHLOTHEIM) BRONGNIART
14. *Pecopteris orientalis* (SCHENK) POTONIÉ
15. *Pecopteris arcuata* HALLE
16. *Pecopteris Anderssonii* HALLE
17. *Pecopteris Wongii* HALLE
18. *Pecopteris hirta* HALLE
19. *Pecopteris taiyuanensis* HALLE
20. *Pecopteris Norinii* HALLE
21. *Pecopteris (Ptychocarpus) unita* BRONGNIART
22. *Callipteridium trigonum* FRANKE
23. *Gigantopteris* ? sp.
24. *Sphenopteris pseudogermanica* HALLE
25. *Alethopteris ascendens* HALLE
26. *Protoblechnum Wongii* HALLE
27. *Taeniopteris latecostata* HALLE
28. *Taeniopteris multinervis* WEISS
29. *Pterophyllum nilssonioides* KAWASAKI
30. *Plagiozamites oblongifolius* HALLE
31. *Cordaites Schenkii* HALLE
32. *Cordaites principalis* GEINITZ

On the basis of these fossils, this series is correlated to the Upper Shih-ho-tzu series in Shan-hsi Province, the Tsai-chia series in Manchuria and the Kobosan (Kopansan) series in Korea, and is regarded now as the Upper Permian formation. Therefore this series which was treated as the Shuang-chuan (?) series in the past, now has the new name of the Huai-jen series given to it by Hikoji MORITA and Chozaburo HASEGAWA.

IV. Geology (III) Upper Coal Measure

A. TA-TUNG SERIES

This series consists of white or light brown sandstone and dark gray or black shale in alternation. It has the thickness of 220 m or so, and covers the Huai-jen series with a disconformity. The relation between this series and the underlying Huai-jen series was regarded as being conformable at the beginning of the map survey, but Chozaburo HASEGAWA observed that the basal conglomerate of this series overlies the Huai-jen series with a distinct unconformity in the upper reaches of E-mao-kou in Huai-jen Prefecture. The southern limit of this series is in Kuo-chia-kou northwest of Huai-jen and in the northern part of the map-sheet area of Ta-ching-kou, where only basal conglomerate remains to cap the mesas. This basal conglomerate changes gradually into conglomeratic sandstone toward the north. The relation between the Ta-tung series and the lower series of formations is not clear in their stratigraphical sequence in the E–W cross section, but is very clear in the N–S cross section. In the southern part of this coal field there is a stratigraphic gap between this series and the Huai-jen series. This gap (time-interval of a missing formation) corresponds to the Shih-chien-feng series of the Tai-yuan district. In the northern margin of the coal field the Ta-tung series directly overlies the Cambrian formation and gneiss and is lacking the formations below the Huai-jen series showing that the gap (hiatus) was very great before the deposition of the Ta-tung series (See Figs. 4 and 6).

The Ta-tung series contains coal seams A, B, C, D, E, F and G, all of which are important workable seams in the North Ta-tung coal field and forms a part of the Upper coal measure.

According to Nikoji MORITA the flora of this series are as follows:

1. *Cladophlebis shansiensis* PAN
2. *Cladophlebis haiburnensis* (LINDLEY and HUTTON)
3. *Cladophlebis gigantea* OISHI
4. *Coniopteris hymenophylloides* BRONGNIART
5. *Hausmania leciane* SZE
6. *Zamiophyllum Buchianum* (ETTINGSHAUSEN)
7. *Nillsonia simplex* OISHI
8. *Ginkgo magnifolia* (FANTAINE)
9. *Czekanowskia rigida* HEER
10. *Phoenicopsis speciosa* HEER
11. *Phoenicopsis angustifolia* HEER
12. *Elatocladus plana* (FEISTMANTEL)
13. *Pagiophyllum setosum* PHILLIPS
14. *Elatides obalis* HEER
15. *Elatides chinensis* SCHENK
16. *Podozamites lanceolatus* (LINDLEY and HUTTON)

The geologic age of the Ta-tung series is regarded roughly as the uppermost Triassic–Lower Jurassic (Rhaetic–Lias).

B. YUN-KANG SERIES

The Yun-kang series was divided into the lower and upper beds, but the lower bed only is now called the Yun-kang series because there is a striking difference between the upper and the lower bed in facies. The upper bed is now called the Nan-hsin series from the name of the bore site of Nan-hsin-chuang. The basal conglomerate of the Yun-kang series varies from 6 to 10 m in thickness and covers the

Ta-tung series unconformably. This unconformity is observed clearly in the valley of Pao-chin and coal seam "A" which is the uppermost seam in the Ta-tung series and the complex involving the seam were eroded away and were not found.

The Yun-kang series is composed of grayish-white sandstone or conglomeratic sandstone, and intercalates one or two layers of conglomerate, several thin layers of greenish-gray shale, and thin coal seams. The total thickness varies from 30 to 100 m, and the famous stone Buddha of Ta-tung is carved in the sandstone of this series at Yun-kang-chen.

Hikoji MORITA collected the following fossils from the horizon, 15–20 m above the base of the Yun-kang series.

1. *Cladophlebis* aff. *gigantea* OISHI
2. *Cladophlebis* sp.
3. *Coniopteris hymenophylloides* BRONGHIART ?
4. *Czekanowskia rigida* HEER
5. *Phoenicopsis speciosa* HEER
6. *Podozamites* ? sp.

There is a conspicuous unconformity seen between Yun-kang series and the Ta-tung series, but no remarkable difference is seen in the fossils and the geologic age is regarded as being Middle or Upper Jurassic period.

C. NAN-HSIN SERIES

This series is composed of sandstone, sandy shale and shale. The sandstone, often containing small bean-sized pebbles, is noticeably false-bedded and is particolored such as grayish white, greenish, yellowish brown, dark-reddish purple, etc. The shale and the sandy shale are on the whole conspicuous dark-reddish purple, often greenish, in color. The type of sedimentation differs even in the same horizon, and concretions of head size are found in some zones.

There are remarkable differences in rock facies and in the state of sedimentation between the Yun-kang series and the Nan-hsin series. The Yun-kang series contains coal, coaly materials and impressions of plant fossils. However, the Nan-hsin series contain no remains of plants. This is a remarkable contrast between the two, and these two series are regarded as forming a disconformity. The geologic age of this series is unknown, but it is provisionally correlated to the Cretaceous (?) Chiu-lung-shan series in Peking-Sishan.

V. Condition of Deposition and Crustal Movement

A. CONDITION OF DEPOSITION AND CRUSTAL MOVEMENT

The condition of deposition of the Upper Paleozoic formation, the Mesozoic coal measure, their relating complex, and the outline of the crustal disturbance will be noted.

The northern portion of this coal field stands on the northern margin of the deposition basin. The marginal facies were affected sensitively even by the slightest disturbance. This disturbance is shown by the unconformities found in every complex, and it is one of the criteria for the determination of crustal movements in the Paleozoic and the Mesozoic eras. Prominent deposition and crustal movements are listed as follows (See Figs. 4 and 6).

a. After the deposition of the Ordovician formation, the land was raised. The amount of upheaval in this movement increased toward the north. As the result, the Ping-ting series was deposited upon the Lower Ordovician formation in the north.

b. In the middle part of the Middle Carboniferous period, small transgression began gradually, and the Ping-ting series was deposited (Kai-luan movement).

c. After the deposition of the Ping-ting series, regression occurred. The Upper Carboniferous period was the time of erosion (earlier stage of the Tzu-hsien movement).

d. In the Lower Permian period transgression started and the Tai-yuan series was deposited in the state of overlap, and thick coal seams and kaolin beds were developed (later stage of the Tzu-hsien movement).

e. Next, regression took place again and erosion was carried out. All deposits thereafter in North China are terrigenous deposits (earlier stage of Chiao-tzu movement).

f. In the Middle Permian period, terrigenous overlapping took place and the Shan-hsi series was deposited. Several layers of thin coal seams were formed in this region too (later stage of Chiao-tzu movement).

g. After the deposition of the Shan-hsi series, epeirogenic movement occurred. The amount of movement was great toward the north. The Shan-hsi series, which is 170 m thick in the map-sheet area of Lao-yao-kou, is not developed from Nan-hsin-chuang to Yun-kang, and the Tai-yuan series, lying beneath the Shan-hsi series is partly eroded (earlier stage of Tsin-pei movement).

h. After this interval of opeirogenic movement and erosion, the Huai-jen series, an inland facies, was deposited (later stage of Tsin-pei movement).

i. After the deposition of the Huai-jen series, opeirogenic movement occurred again. The amount of movement increased from south to north also (earlier stage of the Shan-tung movement).

j. Thereafter, the formation of the basin on a large scale was carried on again, and the deposition of the Ta-tung series, which is the upper main coal measure of this coal field occurred. The Ta-tung series covers the Huai-jen series disconformably in the south, but as one goes to the north it directly covers complexes lower than the Huai-jen series in the area north of the Great Wall of China, it directly covers the Sang-kan gneisses (later stage of Shan-tung movement).

k. After the deposition of the Tai-tung series, this district was upheaved again and eroded. Thereafter, the Yun-kang series containing thin coal seams was deposited accompanied by subsidence (Pao-chin movement).

l. Then, the Nan-hsin series, which is composed of green-colored rocks in red-colored rocks and presents a land facies, was deposited. The age remains unknown because no plant remains have been found yet (Feng-chen movement stage).

m. Thereafter, crustal disturbance of small degree (Heng-shan movement) occurred, and the Hun-yuan series was deposited, which shows that the Yen-shan movement had started. The Yen-shan movement in the North China—the great disturbance which divided the Mesozoic era from the Cenozoic era—took place later.

B. Geologic Structure of the Northern Coal Field

Geological structure seen in the sections from east to west and from north to south will be explained for the purpose of understanding the general geologic structure of the North Ta-tung coal field (See Figs. 5 and 6).

1. *E-W Profile*

The Ta-tung series is deposited almost horizontally in the area from Yung-ting-chuang to Tiao-wo-tsui in the west and as one goes toward the eastern margin the dip to the west increases gradually to be vertical; then the dip changes to the east, and thus the lower horizon appears. Tracing this condition from Kou-chuan, on the eastern margin, to Ping-wang, a thrust structure whose hanging wall has moved from east to west is seen. Many faults striking E–W and dipping 15° to 30°E are found, and coal seams are often compressed to disappear (See Figs. 5 and 6 D–D′). The Ta-tung coal field region appears to be a tableland which has been elevated above the Ta-tung plain. This feature is due to the fact that a complex of hard limestone bent upward forms the eastern wing; this wing protects the coal seams in the west and forms a synclinal mountain.

The Ta-tung coal field, i.e., the Northern, Central and Southern coal fields, extends southwestward. Thrust faults, striking northeasterly are arranged side by side. Every fault is thrusted from the east; the amount of thrust increases toward the south and disappears toward the north. One hinge fault was found in the interior of the coal field (See Fig. 2).

Next, the E–W internal structure of the coal field area between Yung-ting-chuang and Chang-liu-shui will be discussed. The Ta-tung series is nearly horizontal between Yung-ting-chuang and Tiao-wo-tsui as already stated, but as one goes westward from Tiao-wo-tsui to Ssu-lao-kou, Yen-yai, and then to Chang-liu-shui, the rock series of lower horizons appear gradually, and gently dip to the east. Coal seam B occurs about 30 m above the bottom of valley at Tiao-wo-tsui, but coal seam D occurs about 10 m above the road in the vicinity of Ssu-lao-kou. Coal seams E and F appear in the vicinity of Yen-yai. Therefore, even if the difference of altitude above sea level of these points are considered, the Ta-tung series is dipping slightly to the east.

However, the E–W profile of the Tai-yuan series shows that the 20 m bed, which is exposed in Kou-chuan, appears at a depth of 330 m or so below the surface of the bore site at Tiao-wo-tsui, and also at a depth of 400 m or so in the bore at Chang-liu-shui. This results in a dip of 5 degrees or so to the west, even though the differences in altitudes of the bore sites are taken into consideration. The Tai-yuan series shows a dip contrary to the Ta-tung series, and it has been assumed that an unconformity is between the two.

2. *N–S Profile*

In the northern area of the valley from Yung-ting-chuang to Chang-liu-shui, the Ta-tung series is nearly horizontal but dips to northward in the southern area of this valley. As one goes further south the dip gradually increases.

Next, the structural state of the Tai-yuan series in the exposures at Yun-kang, Nan-hsin-chuang, Tiao-wo-tsui bore site and in the southern area south of Lao-yao-kou will be discussed. The series dips to the south in the northern area of Tiao-wo-tsui, namely, at Nan-hsin-chuang and Yun-kang, and it dips to the north in the southern area of Tiao-wo-tsui, and all complexes of the Upper Paleozoic formation generally got thick to the south and thin to the north. This happened because the amount of upheaval was by for bigger in the north than in the south. The northern portion was remarkably eroded before the start of sedimentation of the Upper Paleozoic formation. The overlap was carried on from south to north even at the time of sedimentation. As a result, the northern extremity of the Upper Paleozoic formation is the Ta-tung—Tso-yun road, but the Jurassic formation extends west of Feng-chen north of the Great Wall of China. It must be supposed that a disturbance took place before deposition of the Mesozoic formation. The Paleozoic formation was bent into a synclinal structure with its axis extending from ENE to WSW (See Fig. 6).

3. *General Structure*

The northern limit of the Upper Paleozoic formation in the Northern Ta-tung coal field is the Ta-tung—Tso-yun road. A synclinal structure lies a little south of Tiao-wo-tsui near the northern limit; the synclinal axis extend from ENE to WSW; it was formed before the deposition of the Mesozoic formation. On the other hand the Mesozoic formation forms a synclinal structure with its axis extending from NE to SW between Yung-ting-chuang and Tiao-wo-tsui. On the whole it is to be regarded as gently dipping from northwest to southeast. This synclinal structure in the Mesozoic formation is to be regarded as a local one governed by the thrust movement from east to west (See Fig. 5).

VI. Coal Seams

A. Introduction

The coal seams of this coal field are found in the Yun-kang, Ta-tung, Shan-hsi, and Tai-yuan series. The principal workable coal seams are intercalated in the Ta-tung and in the Tai-yuan series. The mode of occurrence will be discussed next (See Fig. 1).

B. Coal Seams of the Yun-kang Series

The Yun-kang series contains in the lower part two or three layers of thin coal seams, but these are not continuous and are too thin to be worked on a large scale. (Table 2)

Table 2. Modes of Occurence of the Coal seams of the Yun-Kang Series.

Length of exposures on the surface (m)	Thickness (m)	Location
200	1.10	Wu-tui-kou
280	0.65	Yung-ting-chuang, and Wa-yao-kou
120	0.50	SE of Mei-yu-kou
200	0.10–0.15	E. tributary of the Lang-yu-kou (Upper coal)
200	0.05–0.15	E. tributary of the Lang-yu-kou (Lower coal)
unknown	0.41	Pai-tu-yao, Hou-kou (upper coal)
	0.97	Pai-tu-yao, Hou-kou (lower coal)
	0.50	Pao-chin shaft (No. 1) (upper coal)
	0.40	Pao-chin shaft (No. 1) (lower coal)
Boring and shafts	0.90	Mei-yu-kou No. 1 bore (upper coal) of Old Paochin Co.
	0.40	Same as above (lower coal)
	lacking	No. 1 and No. 2 shafts of Old Paochin Mining Bureau
	0.50	No. 3 and No. 5 shafts of the above (one seam only)

C. Coal Seams of the Ta-tung Series

As already stated, the Ta-tung series varies from 214 m to 320 m in thickness, and contains coal seams, A, B, C, D, E, F and G in descending order. The thicknesses and the intervals of the coal seams are as shown in Table 3 (See Fig. 4).

Table 3. Modes of Occurrence of the Coal Seams of the Ta-tung Series.

Coal seams	Thickness (m)	Intervals (m)	Remarks
A	1.2–1.8		Sometimes lacking due to erosion
		45–60	
B	1.6–2.4		
		42–53	
C	1.3–1.6		
		6–10	
D	0.8–1.8		Seams get thinner in the west
		12–28	
E	2.8–4.5		
		20–25	
F	1.2		F_1 and F_2 occur below F in the west
		22	
G	1.2		G_1 occurs below G in the west

The important workable coal seams in this coal field are coal seams B, C and E. Coal seam A is sometimes eroded out because of the unconformity with the upper complex. One or two coal seams occur below coal seams D, F and G. As one goes from the south to the north, the Ta-tung series is deposited in overlap; the lower complex including coal seam G is not developed in the north, and thus coal seam G is not found.

The Ta-tung series, that is the Upper main coal measure, is distributed in the northern and the extreme northernmost regions of the North coal field.[5] It does not occur in the southern part of the North coal field, in the Central and in the South coal field.

D. Coal Seams of the Shan-hsi Series

The Shan-hsi series is 200 m thick at and immediate south of Kuo-chia-kou, and is 170 m thick in the map-sheet area of Lao-yao-kou, but it becomes thin toward the north and is only several meters at the bore-site of Nan-hsin-chuang because of the erosion. As the result among the Upper No. 0 bed, the Upper No. 1 bed and the Upper No. 2 bed, all which occur at Lao-yao-kou, but the Upper No. 0 bed and the complex including the bed are not developed at the bore-site of Tiao-wo-tsui and this series in completely absent at Nan-hsin-chuang. At the bore of Chang-liu-shui, the coal measure of the Shan-hsi series is found but no coal

Table 4. Modes of Occurrence of Coal Seams of the Tai-yuan Series.

Coal seams	Lao-yao-kou map sheet		Chan-fo-ssu and Kuo-chia-kou map sheet		Remarks
	Thickness (m)	Intervals between seams (m)	Thickness (m)	Intervals between seams (m)	
20 m bed	22–27		25–35		About 2 m of shale occur between the upper limit of this bed and the upper limit of this series at Chan-fo-ssu and Kuo-chia-kou. This bed is in direct contact with the Shan-hsi series at Lao-yao-kou.
		13–17		15–20	
Lower No. 1 bed	1.2–2.3		1.5±		
		12–15		15±	
5 m bed			5–6		The distance from this bed to the lower limit of this series: Lao-yao-kou 50m; Chan-fo-ssu and Kuo-chia-kou 30m

5) The north of E–W line connecting Kuo-chia-kou in the upper part of E-mao-kou, Huai-jen-hsien and the northern margin of the sheet map of western Ta-ching-kou.

Table 5. Coal Analysis of

Age	Places, collected	Coal seams	Water %	Ash %	Volatile meter %
Jurassic (Ta-t'ung series) coal	Pai-t'u-yao mine	A	3.92	4.88	29.40
	Pao-chin mine	B	3.92	5.08	32.72
	Yü-feng mine	B	4.23	6.03	25.91
	Yung-ting mine	C	3.16	4.41	28.61
	Tung-chia-liang mine	D	3.26	3.37	30.27
	//	E	2.94	4.83	28.89
	Pai-tung mine	E	2.76	4.86	28.85
	No. 1 well former Shan-ye Co.	F	3.80	4.06	31.74
	Chang-liu-shui Chuan-tze-kou pit	G	3.99	3.62	33.67
Jurassic (Ta-t'ung series) coal		Ta-t'ung coal unscreened	2.67	10.85	28.70
			3.48	15.37	27.24
			2.69	12.37	29.40
			3.21	10.77	28.91
			3.01	12.74	27.86
			4.31	9.53	31.29
			3.22	9.28	29.63
Permian (Ta'i-yuan series) coal	Showa mine, west of Huai-jen	No. 2 bed (20 m bed)	2.94	10.16	38.30
	//	No. 3 bed (20 m bed)	2.85	11.05	32.32
	//	No. 3 bed (20 m bed)	2.68	11.58	32.39
	West of Kou-chuan	20 m bed	2.49	12.82	33.36
	Bore, Tiao-wu-tsui	//	1.98	8.75	33.30
	//	5 m bed	1.64	12.85	32.26
	Bore, Ch'ang-liu-shui	//	1.34	17.12	30.36

* Ministry of Eastern Asia: Table of analysis of raw materials for iron

seam is seen and a thin layer of coaly shale occurs. Thus the coal seams of the Shan-hsi series are variable in both thickness and modes of occurrence. This is due to the fact that the Shan-hsi series is a terrigenous deposit. This phenomenon is common with other coal fields, so complete investigation is necessary before the

Ta-tung Coal Field.*

Fixed carbon %	Total sulphur %	Calorific value Cal.	Fuel ratio	Coking prop.	Remarks
61.80	0.38	7.640	2.10	Contract	Data of Ta-t'ung colliery
58.27	0.38	7.244	1.77	Weak coking	//
63.21	0.60	7.263	2.46	//	//
63.82	0.79	7.747	2.28	Contract	//
63.10	0.72	7.848	2.09	//	//
63.34	0.67	7.665	2.19	//	//
63.55	1.10	7.709	2.20	//	//
60.20	0.42	7.540	1.68	Weak coking	//
58.70	0.87	7.470	1.56	//	//
57.78	0.75	6,860	2.01	Slight coking	Analysed by North China Coal Sale Co.
53.91	0.64	6,463	1.98	//	//
55.54	0.65	6,662	1.89	//	//
57.11	0.30	6,703	1.98	//	//
56.39	0.74	6,697	2.02	//	//
54.87	0.43	6,870	1.75	//	//
57.87	0.76	6,924	1.95	//	//
48.60	0.40	7,040	1.25	Coking	Data of Ta-t'ung colliery
53.78	—	7,000	1.66	//	//
53.35	—	7,070	1.65	//	//
48.67	0.89	6,840	1.46	Swell coking	//
55.97	0.54	7,300	1.68	//	//
53.26	1.29	7,000	1.65	Strong coking	//
51.18	0.94	6,710	1.68	//	//

manufacturing, North China and Mong-chian.

start of operation. The coal seams of this series in this coal field have thicknesses varying from 0.2 m to 0.8 m, and is not good enough be worked.

E. Coal Seams of the Tai-yuan Series

This series forms the Lower main coal measure. Together with the Shan-hsi series all important coal seams of the Lower coal measure are included in this series. Namely the coal seams are, in descending order, the 20 m bed, Lower No. 1 bed, 5 m bed etc. Their modes of occurrence at Lao-yao-kou, at Chan-fo-ssu and in the sheet-map area of Kuo-chia-kou are as shown on Table 4.

The coal seams of this series alternate intimately with partings of kaolin varying from several cm to over 1 m and at times, even up to 12 m in thickness. These partings are of superior quality and nearly pure. Therefore, the actual thickness of the coal is reduced by 30 to 40%. It has been found advantageous to mine the coal together with the partings and then to dress the coal.

The Tai-yuan and the Shan-hsi series are unconformably related, and sometimes a shale bed, varying from 5 to 10 m, in thickness is formed upon the 20 m bed, and sometimes this bed is eroded and the Shan-hsi series is overlaid directly by the 20 m bed. This should be remembered during mining operations (See Fig. 4).

VII. Quality and Reserves of Coal

A. Quality of Coal

The result of the coal analysis from the Ta-tung coal field is shown in Table 5.

1. *Jurassic Coal (Ta-tung Series)*

Most of the coal is bituminous, of low grade and medium grade, extremely low in ash content, high in calorific value, good in ignition, weakly coking and excellent for fuel. And the coal is almost always in lumps, and needs to be crushed into smaller lumps for transportation.

2. *Permian Coal (Tai-yuan Series)*

This is low grade bituminous coal and is mined for lumps. It is high in calorific value and fit to be used as raw material for coke. The coal seam appears black or silver gray in color, and intercalates thickly with thin kaolin layers of a greasy luster so the ash content tends to be high. Thus this coal most be dressed. The ash which remains after burning is pure-white kaolin, and it is used for ceramics or as raw material for the chemical industry. Therefore the working of this coking coal will increase the profit by the sale of kaolin and burnt products. Table 6 shows an analysis outline of the kaolin.

Table 6. Analysis of the Ta-tung Kaolin.

Silica	Alumina	Ferric oxide	Lime	Magnesia	Titan	Ignition loss	Refractoriness
42%	40%	0.8%	Less than 1%	Less than 0.2%	Less than 0.4%	14%	SK 34–35

B. Characteristics, Viewed from Coal Mining

Being worked now are B bed, C bed and E bed of the Ta-tung series, and the coal seams of the Tai-yuan series are only partly bored. The advantages and disadvantages of these seams for the mining are as follows.

1. *Advantages*

a. The coal seam is hard and compact, which minimizes the consumption of timber, 0.8 sai per ton of coal (average consumption at collieries in North China is 5 sai, and average in Manchuria is 8 sai).

b. Combustible gas is not prevalent[6)] so instead of electric safety lamps, carbide lamps can be used safely in most mines.

c. Yield of water from the mine is small. It is less than 100 cubic feet per minute in all pits (50 cubic feet in Yung-ting-chuang pit, 44 cubic feet in Mei-yu—Yu-feng pit, 27 cubic feet in Pao-chin pit).

d. The dips of the coal seams are gentle, and the faults are few, so the mining operations can be mechanized.

e. The coal seams of the Ta-tung series has few partings, and low in ash-content. Machine is needed only for sizing, and washing is not necessary.

Table 7. Probable Reserves of the North Ta-tung Coal Field (See Fig. 3).

No.	Sheet map	Probable reserves in metric tons			Surveyed by
		Jurassic coal	Permian coal	Total	
1	Yung-ting-chuang	53,640,000	225,230,000	278,870,000	MORITA
2	Pai-tung-tsun	145,390,000	220,150,000	365,540,000	MORITA TAKAHASHI
3	Yin-tang-kou	195,660,000	315,900,000	511,560,000	MUKAI
4	Ssu-lao-kou	44,070,000	89,660,000	133,730,000	ONUKI
5	Yen-yai-wei	140,960,000	372,600,000	513,560,000	〃
6	Wei-chia-kou	152,490,000	337,180,000	489,670,000	〃
7	Lao-yao-kou	79,970,000	447,870,000	527,840,000	〃
8	Chang-liu-shui	90,150,000	335,340,000	425,490,000	〃
9	Mei-yu-kou	21,170,000	40,820,000	61,990,000	〃
10	Yu-feng colliery	172,430,000	133,810,000	306,240,000	MORITA TAKAHASHI
11	Pai-tu-yao	250,900,000	254,340,000	505,240,000	MORITA MUKAI
12	Pao-chin	183,560,000	194,400,000	377,960,000	CHANG-Li-hsu
13	Nan-hsin-chuang	255,690,000	240,570,000	495,660,000	〃
Total		1,786,080,000	3,207,870,000	4,993,350,000	

6) Ground water gushed out of the Ta-tung series to a height of about 10 m during boring operations at Yun-kang-chen in the fall of 1941. The volume of water and its pressure were reduced shortly; the volume settled at 18 l/m, and remained constant for three years. The water was being used for drinking, miscellaneous uses, and for irrigation. It is noteworthy that combustible gas issued along with the water (according to Chozaburo HASEGAWA).

f. The coal seams of the Tai-yuan series contain kaolin, and if the run-of-mine is dressed by machine, raw material for ceramics of excellent quality can be recovered.

g. The coal of the Ta-tung series is steam coal, while the coal of the Tai-yuan series is coking coal. Thus, coals of two kinds are obtained in the same coal field.

2. *Disadvantages*

a. Working conditions are not good—80% of the native workers are opium-eaters; they are poor in persistence; and they go home during the farming season.

b. Materials are almost wholly dependent on outside sources.

c. Subsurface part of the outcrop has been mined to the depth of about 70 m by old primitive methods, and there are many old pits filled with water. Therefore sufficient investigation and time are necessary when opening new pits.

d. The exploitation area is confined in valleys because of topography; valleys are narrow and sites for surface installations are small, and discharge is temporarily large in the rainy season, often devastating surface installations.

e. The water is hard (over 35°) and damages the boiler facilities.

C. Coal Reserves

The reserves in this coal field were calculated in terms of coal seams and geologic age during the survey of the 13 sheet maps as shown in Table 6, but the values on the whole are only general estimates.

1. *North Coal Field*

a. Probable reserves of the sheet map area in the North coal field (13 map sheets) are as follows (See Table 7, Fig. 3):

Jurassic coal	1,800,000,000 tons
Permian coal	3,200,000,000 tons
Total	5,000,000,000 tons

b. Possible reserves of the remaining area in the North coal field are as follows:

Jurassic coal (34 map sheets)	4,000,000,000 tons
Permian coal (33 map sheets)	6,600,000,000 tons
Total	10,600,000,000 tons

2. *Northernmost Coal Field*

Possible reserves of the northernmost coal field are as follows:

Jurassic coal (32 map sheets)	3,200,000,000 tons

3. *Central Coal Field*

Possible reserves of the Central coal field are as follows:

Permian coal (71 map sheets)	12,700,000,000 tons

4. *South Coal Field*

Possible reserves of the South coal field are as follows:

Permian coal	9,000,000,000 tons

5. The total reserves of this coal field are estimated at over 40,000,000,000 tons, as shown in Table 8.

Table 8. Possible Coal Reserves of the Ta-tung Coal Field (ton).

		Permian coal	Jurassic coal	Total
Northernmost coal field			3,200,000,000 (32)	3,200,000,000
North coal field	(a)*	3,200,000,000* (13)	1,800,000,000* (13)	5,000,000,000
	(b)	6,600,000,000 (33)	4,000,000,000 (34)	10,600,000,000
Central coal field		12,700,000,000 (71)		12,700,000,000
South coal field		9,000,000,000 (60)		9,000,000,000
Total		**31,500,000,000** (177)	**9,000,000,000** (79)	**40,500,000,000**

* Probable reserves. (by ONUKI, 1945)
( ) Number of map sheets.

VIII. Conclusion

a. The Sang-kan gneiss and the Cambro-Ordovician formation form the basement of this coal field, and the Upper Paleozoic formation and Mesozoic formation are distributed upon them to form the Ta-tung coal field.

b. The Ta-tung coal field area is divided into the Northernmost coal field, the North coal field, the Central coal field and the South coal field. The Upper Paleozoic formation occurs in the North, the Central and the South coal field, and does not occur in the Northernmost coal field. The Mesozoic formation is developed in the Northernmost and the North coal field, but does not occur in the Central and the South coal field.

c. The Upper Paleozoic and the Mesozoic formations are distributed in the North coal field. This field is the most important for geological study; it is easily accessible, and is most suited for exploitation.

d. The Ta-tung coal field is located in the northern marginal region of the Great North China coal field, and from the viewpoint of sedimentary facies, it is situated in the southern foot-region of the Yin-shan mountain range, and appears on the marginal facies of a sedimentary basin. This means that the slightest crustal movement could affect this coal field much more than any other coal field. This coal field presents various kinds of data for the study of crustal movements.

e. The Upper Paleozoic formation is divided into the Ping-ting, Tai-yuan, Shan-hsi, and Huai-jen series; the Mesozoic formation is divided into the Ta-tung, Yun-kang, Nan-hsin, and Hun-yuan series. The Hun-yuan series does not occur in the Ta-tung coal field, but it is developed in the Hun-yuan coal field in the southeast.

f. Looking over the mutual relations among the complexes of all the series, the relations are always unconformable. This applies especially to the unconformity between the Upper Paleozoic formation and the Mesozoic formation which tells us the crustal movement at that time involved folding.

g. Coal seams are intercalated mainly within the Tai-yuan series and the Ta-tung series. The former is named the Lower main coal measure and the latter the Upper main coal measure.

h. The coal of the Tai-yuan series is coking coal, while that of the Ta-tung series is non-coking or weakly coking coal. Coals of two kinds are produced in the same coal field. This makes the coal field more important.

i. The reserves of this coal field are estimated at over 40,000,000,000 tons.

Reference

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