Carboniferous and Permian Systems of Manchuria

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I. Introduction

There are two different kinds of sedimentary facies in the Manchurian Carboniferous and Permian Systems. One is the South Manchurian type which is represented by the Taitzuho System, containing coal and marine formations, and the other is the North Manchurian type which is represented by the Touman and Chilin Formations of marine facies. The boundary between the two types is not clear-cut, but they can be distinguished as follows: The vicinities of Hoeryeong in Korea and Yen-chi Hsien north of the former are situated at the western rim of the Touman formation; the vicinity of Chiao-yang-chen on the Shen-Chi Railway is located at the southern end of the Chilin Formation; the Carboniferous and Permian Systems in the vicinities of Fu-sung, Meng-chiang and Hui-nan in Antung Province belong to the Taitzuho System. Farther west, the Taitzuho System is most typically developed along the Tai-tzu Ho river and is not found in any area north of the watershed between the Tai-tzu Ho and Hun Ho rivers.

In the southwestern part of Manchuria, the South Manchurian type is extensively developed south of the railroad between Chiao-yang and Cheng-te, whereas the North Manchurian type is largely distributed in the vicinity of Lin-hsi in the upper reaches of the Shramuren River and in the area farther north. Therefore, the boundary between the two types may cross the northwestern part of Jeho Province and extend farther west to the north side of the Yen-shan Mountains.

What, then, is the geological meaning of this boundary line? It may have only paleogeographical meaning, or it may also have some tectonic meaning. In any case, this problem needs more detailed studies in association with the investigation of the so-called Mongolian Geosyncline.

II. The Carboniferous and Permian Systems in South Manchuria

1. General description

In South Manchuria the marine Middle Carboniferous System rests extensively in parallel unconformity on the marine Middle Ordovician System. The marine,

lacustrine, and fresh-water sediments of the coal measures of the Permian system are developed, in turn, parallel-unconformably on the Middle Carboniferous System. Since these stratigraphic relations are completely the same as in North China and Korea, one must refer to the stratigraphy of these districts to study the later Paleozoic System in South Manchuria.

A. Taitzuho district and southern part of the Liao-tung Peninsula

The name Taitzuho System was given by Takao SAKAMOTO[42] to the Carboniferous and Permian Systems in South Manchuria. The writer[24-26, 28, 30-32, 35-37] studied the geology of this system for many years and the results of this study in the Tai-tzu-ho district and the southern part of the Liao-tung Peninsula are summarized in Table 1.

Table 1. Stratigraphic Sequence in the Taitzuho System.

	Miyanohara formation	Lower Cretaceous
Taitzuho System	Tsaichia Series	Upper Permian
	Liutang Series	Lower Permian
	Huangchi Series (Yatang Series)	Lower most Permian
	Penhsi Series	Middle Carboniferous
	Ssuyen Series	Middle Ordovician

All boundaries are unconformable except the boundary between the Huangchi Series (Yatang Series) and the Liutang Series. Moreover, in the Niu-hsin-tai coal field, the strata of unknown age are developed unconformably between the Penhsi Series and Ssuyen Series.

The distribution area of the Taitzuho System in South Manchuria is divided into two districts, the Tai-tzu-ho district and the southern part of the Liao-tung Peninsula. To the Tai-tzu-ho district belong the coal fields of Yen-tai (Fig. 5), Chang-tai-tzu, Han-po-ling (where the Penhsi Series alone is developed), Penhsi-hu (Fig. 6), Niu-hsin-tai (Fig. 7), Tao-yuan-kou, Pien-ling, Hsiao-shih and Tien-shih-fu-. To the Liao-tung district belong the coal fields of Fu-chou (Fig. 8), Tiao-hu-chu (where the Penhsi Series alone is developed), Chien-shih-hui-yao-tun and Tung-chia-kou.

The generalized explanation for the Taitzuho System along the Tai-tzu Ho and in the southern part of the Liao-tung Peninsula is given below.

a. Penhsi (Penchi) Series

This series was named by LEE and CHAO[14] with Pen-hsi-hu as its type locality. In general, the Penhsi Series rests with parallel unconformity upon the Ssuyen Series of the Middle Ordovician, and belongs to the Middle Carboniferous Moscovian. It consists mainly of alternating shale and sandstone, intercalated with several layers of limestone. The predominant color of this series is characteristic reddish ochre. Reddish-ochre shales are remarkably developed in the basal part. It often contains aluminous shale, fire clay and thin coal seams. Nodular limonite

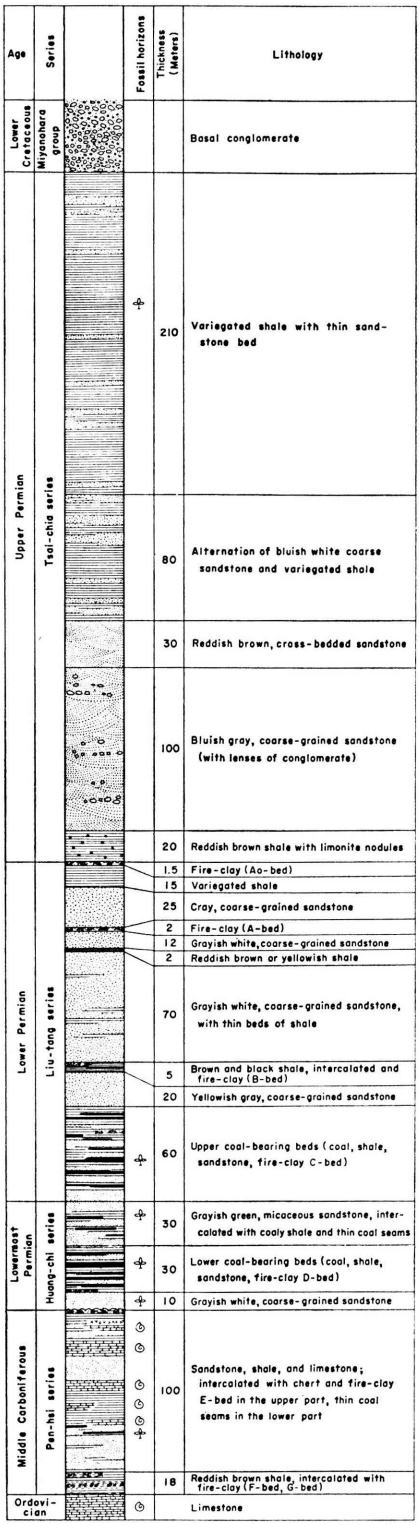

Fig. 1. Geologic Columnar Section of the Pen-hsi-hu Coal Field.

ore is found in the reddish-ochre aluminous shale. In the Tai-tzu-ho district, black to grayish lenticular cherts are sometimes found in the upper part of the series. The total thickness of this series is estimated to be 70 to 90 m in southern Liao-tung Peninsula, and about 120 m in the Tai-tzu-ho district. Its age is assigned to the Middle Carboniferous Moscovian on the basis of the following fossils:

Foraminifera

Nodosinella padangensis LANGE
Cribrogenerina cf. *permica* LANGE
Textularia exima D'EICHWALD
T. thorax LANGE
T. cf. *gibbosa* D'EICHWALD
Climacammina antiqua BRADY
Tetrataxis parviconica LEE and CHEN
Lagena permica LANGE
Bradyina nautiliformis V. MÖLLER
B. cf. *rotula* (D'EICHWALD)
Staffella spaeroidea (V. MÖLLER)
S. confusa LEE and CHEN
Ozawainella angulata (COLANI)
Fusulinella chaoi (LEE)
F. bocki V. MÖLLER
F. biconica (HAYASAKA)
F. colani (LEE and CHEN)
F. praesimplex (LEE)
F. irumensis HUZIMOTO
F. cf. *rhomboides* (LEE and CHEN)
Boultonia willsi LEE
Schubertella magna LEE and CHEN
Fusulina Konnoi (OZAWA)
F. cylindrica FISCHER DE WALDHEIM
F. teilhardi (LEE)
F. cf. *pankouensis* (LEE)

Brachiopoda

Spirifer (*Choristites*) *mosquensis* FISCHER
S. (*Ch.*) *jigulensis* STUCKENBERG
S. (*Munella*) *nikitini* TSCHERNYSCHEW
S. (*M.*) *tschernyschewformis* OZAKI
Squamularia asiatica CHAO
Martinia semiplana WAAGEN
Marginifera timanica TSCHERNYSCHEW
Camarophoria meyeri tetraplicata OZAKI

Corals

Arachnastraea manchurica YABE and HAYASAKA

A. manchurica forma *sinuoseptata* YABE and EGUCHI
A. manchurica forma *coreanica* YABE and EGUCHI
A. molleri STUCKENBERG
Cystiphora manchurica YABE and HAYASAKA
C. manchurica forma *podolskiensis* DOBROLIUBOVA
C. manchurica forma *humboldti* (STUCKENBERG)
C. manchurica forma *kikkawai* YABE and HAYASAKA
Syringopora reticurata GOLDFUSS
Chaetetes asiaticus YABE and HAYASAKA

Some plant remains, such as *Lepidodendron aculeatum* STERNB. and *Calamites* cf. *Suckowi* (BRONGN.), are found in the carbonaceous shale in the middle part of the series, which further justifies its assignment to the Moscovian.

b. Huangchi Series (Yatang Series)

The type locality of the Huangchi Series is Huang-chi-kou, about 3km west of Pen-hsi-hu. In both lithology and fauna, the series in the Tai-tzu-ho district is remarkably different from that in the southern Liao-tung district, as the former contains no limestone while the latter is intercalated with many layers of limestone; the features of the latter are quite identical with those of the lower part of the Jido Series in Korea and the Taiyuan Series in North China. Therefore, Shōshirō HANZAWA[7] proposed the name Yatang Series for the writer's Huangchi Series in the southern Liao-Tung, taking the name of Ya-tang Bay.

In every coal field of Manchuria, the unconformity at the base of Permian is very distinct paleontologically and stratigraphically.

Along the Hun Chiang river, Tung-pien-tao, a distinct unconformity is found between the Penhsi Series and the Takang Series, which is the Permian coal-bearing formation, as will be mentioned later. [29,35] The writer[34,29] also found an unconformity at the base of the Taiyuan Series in North China, which is equivalent to the Yatang Series. These unconformities are the most important data verifying the absence of the Upper Carboniferous Urlian. This is the basis on which the writer defined the base of Permian.

The Huangchi Series in the Tai-tzu-ho district consists of sandstone, sandy shale, shale, fire-clay and coal, and constitutes the so-called Lower coal-measures in this district. The total thickness of the series is estimated to be about 70 m.

In the shale of this series many plant fossils listed in Table 2 are found, and 15 genera and 20 species are identified. Among them, more than 8 genera, including *Lobatannularia, Emplectopteridium,* and *Tingia,* are characteristic to the Orient.

Thus, it is recognized that the Oriental flora was already rather remarkably differentiated. As an element of Mesozoic flora, there is only one species of genus *Cladophlebis*. By reference to 9 species common to Europe and the Orient, the geological age of this series is assigned to the Stephanian to Lower Rotliegende, as seen in Table 3.

For a detailed determination of the geological age, more precise correlation with North China and Korea is needed. The writer referred to the data by T. G.

Table 2. List of Fossil Plants in the Taitzuho System.

Series / Locality / Fossil	Penhsi series	Huangchi series (Yatang series)			Liutang series			Tsaichia series
	Pen-hsi-hu	Pen-hsi-hu	Yen-tai	Fu-chou	Pen-hsi-hu	Yen-tai	Fu-chou	Pen-hsi-hu
1. *Calamites Suckowi* (BRONGN.)	×	•	×	×	×			
2. *C.* cf. *Cisti* BRONGN.	•	•	×	•	×			
3. *C.* sp.	•	•	×	×	×	×		
4. *Annularia orientalis* KAWASAKI	•	•	×	•	×	×		
5. *A. stellata* (SCHLOTH.)	•	•	×	•	•	×		
6. *Lobatannularia sinensis* HALLE	•	•	×	•	•	×		
7. *L. inequifolia* (TOKUNAGA)	•	•	•	×	•	•	×	
8. *Sphenophyllum oblongifolium* (G. et K.)	•	•	×	•	×	×	×	
9. *Sph. emarginatum* BRONGN.	•	•	•	•	×			
10. *Sph. verticillatum* SCHLOTH.	•	•	×					
11. *Sph. orientale* KAWASAKI	•	•	•	•	×			
12. *Sph. Thonii* MAHR	•	•	•	•	×	×	×	
13. *Sph.* sp.	•	•	•	•	•	•	•	×
14. *Bowmanites laxus* HALLE	•	•	×					
15. *Pecopteris hirta* HALLE	•	•	•	•	×	×		
16. *P. polymorpha* BRONGN.	•	•	•	•	•	×	×	
17. *P. tuberculata* HALLE	•	•	•	•	×			
18. *P.* cf. *cyathea* (SCHLOTH.)	•	•	•	•	×			
19. *P.* sp.	•	•	•	•	×	•	×	×
20. *Pecopteridium manchuricum* KAW.	•	•	•	•	×			
21. *Cladophlebis Nystroemii* HALLE	×	•	×	•	×	•	×	×
22. *Neuropteris* spp. (n. sp.)	•	×	×	•	×	×	•	×
23. *Neuropteridium? yongwolensis* KAW.	•	•	×	×	×			
24. *Callipteridium koraiense* (TOKUNAGA)	•	•	×	•	•	×	×	
25. *Odontopteris? subcrenulata* (ROST)	•	•	×					
26. *O.* sp.	•	•	•	•	•	×	×	
27. *Emplectopteris triangularis* HALLE	•	•	•	•	×	×		
28. *Emplctopteridium alatum* KAW.	•	•	×	•	•	×	×	
29. *Protoblechnum Wongii* HALLE	•	•	•	•	•	×	×	
30. *Taeniopteris multinervis* WEISS.	•	•	•	•	×			
31. *T. Schenki* STERZEL	•	•	•	•	×			
32. *T. punctulata* KAW.	•	•	•	•	×			
33. *T. Nystroemii* HALLE	•	•	•	•	×			

Table 2. (Continued)

Fossil \ Series / Locality	Penhsi series	Huangchi series (Yatang series)			Liutang series			Tsaichia series
	Pen-hsi-hu	Pen-hsi-hu	Yen-tai	Fu-chou	Pen-hsi-hu	Yen-tai	Fu-chou	Pen-hsi-hu
34. *T. Tingii* HALLE	•	•	•	•	×			
35. *T. taiyuanensis* HALLE	•	•	•	•	•	•	×	
36. *T. serrulata* HALLE	•	•	•	•	•	•	×	
37. *T.* sp. *a* (n. sp.)	•	•	•	•	×			
38. *T.* sp. *b* (n. sp.)	•	•	•	•	•	•	•	×
39. *Gigantopteris nicotinaefolia* SCHENK	•	•	•	•	•	•	×	
40. *Chiropteris reniformis* KAW.	•	•	•	•	•	•	×	
41. *Lepidodendron oculisfelis* (ABB.)	•	×	×	•	×	•	×	
42. *L. orientale* KOIWAI	•	•	×					
43. *L. Yabei* KOIWAI	•	•	•	•	•	•	×	
44. *L. Gaudryi* RENAULT	•	×	×	•	×			
45. *L. aculeatum* STERNB.	×							
46. *L.* sp.	•	×	×	•	×			
47. *Lepidostrobus* sp.	•	•	•	•	•	•	×	
48. *Sigillaria* sp. (n. sp.)	•	•	•	•	×			
49. *Sigillariostrobus*? sp.	•	•	•	•	×			
50. *Stigmaria asiatica* JOHGM. et GOT.	•	×	×	•	×	×	×	
51. *S. ficoides* (STERNB.)	×	×	×	•	×	×	×	
52. *Cordaites principalis* (GERM.)	•	×	×	•	×	•	×	
53. *C. Schenkii* HALLE	•	×	×	×	×	×	×	×
54. *C. parvifolius* KAW.	•	•	•	•	×			
55. *C.* spp.	•	×	•	•	×	×		
56. *Cordaicarpus* sp.	•	•	•	•	×			
57. *Cordaianthus* sp.	•	•	•	•	×			
58. *Samaropsis*? *taiyuanensis* HALLE	•	•	×					
59. *S.* sp.	•	•	×	•	×	•	×	
60. *Trigonocarpus*? *Norinii* HALLE	•	•	•	•	×			
61. *Tingia carbonica* (SCHENK)	•	•	•	•	•	•	×	
62. *T. Hamaguchii* KONNO	•	•	×	•	×	•	×	
63. *T. Kikkawai* (TOKUNAGA)	•	•	•	•	•	•	×	
64. *T. elegans* KONNO	•	•	•	•	•	•	×	
65. *T.* sp. (n. sp.)	•	•	•	•	×			
66. *Baiera* spp.	•	•	•	•	•	×	•	×

Table 3. Vertical Range of the Plant Fossils in the Huangchi Series Which are Common with European Flora.

Specific Name \ Age	Carboniferous						Permian		
	Dinantian	Namurian	Westphalian			Stephanian	Rotliegende		Zechstein
			L.	M.	U.		L.	U.	
Calamites Suckowi (BRONGN.)	×	×	×	×	×	×	×	×	
C. Cisti BRONGN.	•	•	×	×	×	×	×		
Sphenophyllum oblongifolium (G. et K.)	•	•	•	•	•	×	×		
Sph. verticillatum SLOTH.	•	•	•	•	•	×	×		
Odontopteris subcrenulata (ROST)	•	•	•	•	•	×	×		
Callipteridium trigonum FRANKE (syn. *C. Koraiense* TOKUNAGA)	•	•	•	•	•	×	×		
Lepidodendron Gaudryi RENAULT	•	•	•	•	•	×	×		
Stigmaria ficoides (STERNB.)	×	×	×	×	×	×	×		
Cordaites principalis (GERM.)	•	•	×	×	×	×	×		

HALLE[6] in Shan-hsi and by KAWASAKI[10] in Korea, and recognized that the Huangchi Series is to be correlated with the lower part of the Yuehmenkou Series, namely the Taiyuan Series in Shan-hsi and the lower part of the Jido Series in Korea. Though characteristic fusulinid fossils of the Sakmarian have not yet been found, the writer concluded that the Huangchi Series belongs to the lowermost part of the Permian Period on the basis of the above considerations. Since then, many marine animal fossils have been found from the Huangchi and Liutang Series in the Tai-tzu-ho district, and these will be mentioned in the paragraph on the Liutang Series.

The Yatang Series in the southern part of the Liao-tung Peninsula is composed of the so-called black-rock group, and constitutes the Lower coal-measures, as in the Tai-tzu-ho district. At its type locality in the Fu-chou coal field (Fig. 8), the Yatang Series consists of shale, sandy shale, sandstone, limestone, chert, fire-clay and coal. The total thickness is about 100 m. The fire-clay beds are always developed at the base of this series.

In Fu-chou the following fossils are abundant in the limestone and shale of this series.

Foraminifera

Nodosinella padangensis LANGE
Textularia exima D'EICHWALD
T. thorax LANGE
Cribrostomum molleri LEE and CHEN
Climacammina sp.

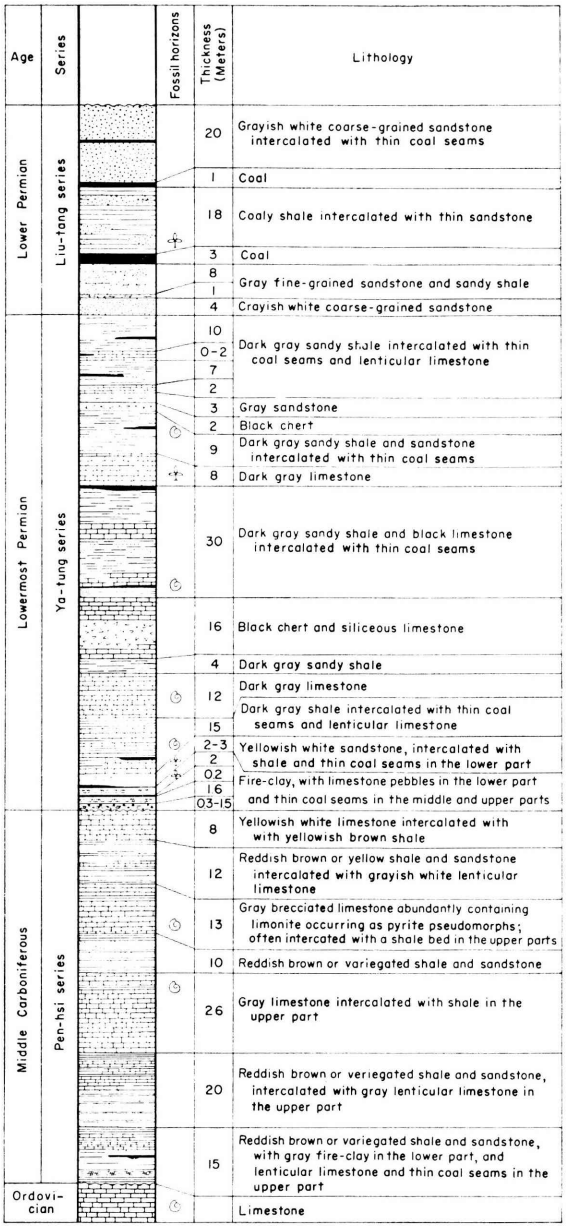

Fig. 2. Geologic Columnar Section of the Fu-chou Coal Field.

Tetrataxis parviconica LEE and CHEN
T. schellwieni OZAWA
T. planolocula LEE and CHEN
Ozawainella angulata (COLANI)
Quasifusulina longissima (v. MÖLLER)

Qu. longissima var. *tenuis* (LEE)
Schwagerina richthofeni (SCHWAGER)
Sch. expansa (LEE)
Sch. vulgaris cf. var. *kozui* (LEE)
Pseudoschwagerina glomerosa (SCHWAGER)
Ps. muongthensis (DEPRAT)

Brachiopoda
Productus taiyuanfuensis GRABAU
P. cf. *volgensis* STUCKENBERG
Derbyia hemispherica WAAGEN
Streptorhynchus kayseri SCHENK
Martinia semiplana WAAGEN
Chonetes semicircularis CHAO

Pelecypoda
Lima sp.
Limatulina sp.
Pseudomonotis sp.
Nuclopsis anthraconeilloides CHAO

Cephalopoda
Huanghoceras linchengense YIN

Bryozoa and crinoides
Genus and species indet.

There is no doubt that the geological age of this series is Sakmarian and is correlated with the Taiyuan series in North China, as well as with the lower part of the Jido series (coal-measures) in Korea.

Moreover, in Fu-chou, such plant fossils as *Calamites Suckowi* (BRONGN.), *Annularia stellata* (SCHLOTH.) and *Cordaites Schenkii* HALLE are found in shale accompanied by limestone in this series.

c. Liutang Series

The Liutang Series constitutes the so-called Upper coal-measures and rests conformably on the Huangchi Series. The type locality is the Liutang Mine, 2.7 km west of Pen-hsi-hu (Fig. 6). This series does not crop out in the southern part of the Liao-tung Peninsula except at Fu-chou, where its lower part alone is developed. However, its lithic character and fossils are almost identical with those of the Tai-tzu-ho district.

This series consists of sandstone, shale, fire-clay and coal, without limestone. Coal is found mostly in the lower part, while the sandstone is richly developed in the upper part. Shales of the lower part are carbonaceous, while those of the upper part are red-ochre or green and are associated with good aluminous shales and fire-clay bed A. The total thickness of the series is estimated to be about 170 m.

Many well-preserved plant fossils are found in the carbonaceous shales in the lower part of this series, and important species are listed in Table 2. Among them, 19 genera and 41 species are identified. Chatacteristic Oriental plants such as

Table 4. Vertical Range of the Plant Fossils in the Liutang Series Which are Common with European Species.

Species \ Age	Carboniferous						Permian		
	Dinantian	Namurian	Westphalian			Stephanian	Rotliegende		Zechstein
			L.	M.	U.		L.	U.	
Calamites Suckowi (BRONGN.)	×	×	×	×	×	×	×	×	
C. Cisti BRONGN.	•	•	×	×	×	×	×		
Annularia stellata (SCHLOTH.)	•	•	•	•	×	×	×		
Sphenophyllum Thonii MAHR	•	•	•	•	•	×	×		
Sph. oblongifolium (G. et K.)	•	•	•	•	•	×	×		
Sph. emarginatum BRONGN.	•	•	•	•	•	×	×		
Pecopteris polymorpha BRONGN.	•	•	•	•	•	×	×		
Callipteridium trigonum FR. (*C. koraiense* T.)	•	•	•	•	•	×	×		
Taeniopteris multinervis WEISS	•	•	•	•	•	•	×		
T. Schenki STERZEL	•	•	•	•	•	•	×		
Lepidodendron Gaudryi RENAULT	•	•	•	•	•	×	×		
Stigmaria ficoides (STERNB.)	×	×	×	×	×	×	×		
Cordaites principalis (GERM.)	•	•	×	×	×	×	×		

Lobatannularia, Pecopteridium, Emplectopteris, Emplectopteridium and *Tingia* are predominant, occupying about 2/3 of the total number. Therefore, the differentiation of the Far Eastern floral province in this series is more remarkable than in the Huangchi series. As seen in Table 2, 26 species make their first appearance in this series and are characteristic to it. However, *Neuropteridium, Chiropteris, Taeniopteris* and *Cladophlebis* are Mesozoic floral elements.

Among the flora in this series, 13 species are common with European species; their geological age is given in Table 4. *Taeniopteris multinervis* WEISS and *T. Schenki* STERIEL are especially characteristic to the Lower Rotliegende of Europe, and *Sphenophyllum Thonii* MAHR is abundant in the same age. Therefore, there would be no objection to assigning this series to the Lower Rotliegende.

The writer also compared the plant fossils of this series with that of Shan-hsi. The results indicate that this series almost corresponds to the upper part of the Yuehmenkou Series. If it is younger, it is perhaps equivalent to the basal part of the Lower Shihhotzu Series. It is clear, however, that this series is contemporaneous with the upper part of the Jido Series in Korea, from the comparison with the plant fossils in the Heian System.

Three collected specimens of *Chiropteris reniformis* KAWASAKI are noteworthy. This species is found only in the upper part of the Kobosan Series in Korea and

Shihhotzu Series in Shan-hsi. From this standpoint the geological age of the Liutang Series in Fu-chou must be reconsidered.

Mention should be made also of the sedimentation facies of the Huangchi and Liutang Series in the Tai-tzu-ho district. Formerly, Tsutomu OGURA[39] had found abundant radiolarian species and sponge spicules from the shale and pyritiferous nodules in the Huangchi Series at Pen-hsi-hu and Yen-tai, as well as *Ammodiscus*—siliceous foraminifera—from the shale in the Liutang Series, and he concluded that the coal-measures in these districts are of brackish deposition while the inter-coal beds are pure marine sediments.

Since then, the writer[31,32] collected many specimens of small gastropod fossils, namely *Sphaerodoma r-endoi* NODA, *Sph.* sp. and *Naticopsis* sp. from four layers of black limestone, 20–50 cm thick, intercalated within the black shale, about 5 m in thickness, that overlies the coal seam in the lower part of Huangchi Series, south of Chuan-chia-pu-tzu, Tien-shi-hu coal field. *Cordaites* sp. and *Stigmaria* sp. were collected from the gray sandstone, intercalated with black shale, which lies about 20 m above the uppermost layer of limestone. Therefore, it is clear that these limestone layers must belong to the Huangchi Series.

The writer also collected the following animal fossils from the dark gray shale in the lower part of the Liutang Series, which crops out in the gully west of Hsiao-nan-kou, Niu-hsin-tai coal field.

Brachiopoda

Chonetes latesinuata (SCHLOTH.)
Ch. pygmaea LOCZY
Ch. substromenoides HUANG
Ch. spp. (n. sp.)
Waagenoconcha cf. *purdoni* (DAVID.)
Productus taiyuanfuensis GRABAU
P. gruenewaldti KROTOW
Marginifera pusilla SCHELLW.
Linoproductus koninchianus (VERNEUIL)
L. sp.
Striatifera sp.
Schellwienella regularis HUANG
Sch. sp.

Pelecypoda

Aviculopecten manchuriensis CHAO
Lima striatoplicata CHAO
Nuclopsis sp.

Gastropoda

Paromphalus cf. *mapingensis* GRABAU

Cephalopoda

Orthoceras sp.
Aphelocerus sp.

Corals

Genus and species indet.

Crinoid stems

Plant fossil

Cordaites principalis (GERM.)

The fact that many marine animal fossils were found from the Huangchi and Liutang Series in several places in the Tai-tzu-ho district strengthens OGURA's and the writer's conclusions that marine sediments are often present in the Huangchi and Liutang Series. Naturally, some differences in lithic character may be found between the Huangchi Series in the Tai-tzu-ho district and the Yatang Series in the southern part of the Liao-tung Peninsula. However, the differences are largely whether the sediments are limy or sandy and whether *Pseudoschwagerina* and *Schwagerina* are present or not. Both series have undergone marine transgression.

d. Tsaichia Series

A thick complex of quartz sandstone and variegated shale, covering the Liutang Series, belongs to the Tsaichia Series. Its type locality is Tsai-chia-tun along the Tai-tzu Ho river, about 4 km south of Pen-hsi-hu. Its total thickness is estimated to be about 440 m. This series does not crop out in the southern part of the Liao-tung Peninsula but it is especially well developed in the vicinity of Pen-hsi-hu in the Tai-tzu-ho district.

At a glance, the relation between the Liutang and Tsaichia Series seems conformable. However, it is observed that the Tsaichia Series rests in distinct clino-unconformity on bed A of the upper part of the Liutang Series in the aluminous shale mine at Tzu-erh-shan near Yen-tai and Lao-tung-tai, Hsiao-shih.

B. Fun-chiang district

The Taitzuho System crops out extensively in the so-called Tung-pien-tao area, an eastern prolongation of the Tai-tzu-ho district. The writer[29] surveyed the Taitzuho System at Te-chang-tzu, Wu-tao-chiang, Ta-t'ung-kou and Lao-huan-tzu-kou, An-tung Province along the Hun Chiang river, and subdivided the system into the Penhsi, Takang and Techang Series in ascending order.

a. Penhsi Series

The Penhsi Series of the Hun-chiang district rests unconformably on the Ordovician limestone and consists mainly of black shale and gray sandstone intercalated with several thin seams of coal and limestone. A comparison of its lithic characters with those of the Tai-tzu-ho district shows the following differences: A basal conglomerate, 1–2.5 m thick, is developed in this district; the development of aluminous shale or fire-clay is remarkably poor; the color of the rocks is noticeably dark black, and ochre rock is rather rare; its total thickness is estimated to be about 100 m in general, but it sometimes reaches 270 m; limestone layers are found only in its upper part and are remarkably thin; many marine animal fossils are found in the limestone, indicating that it belongs to the Middle Carboniferous Moscovian. The most important fossils are listed below.

Foraminifera

Nodosinella sp.
Textularia exima D'EICHWALD
T. thorax LANGE
Climacammina antiqua BRADY
C. longissimoides (LEE and CHEN)
Tetrataxis minima LEE and CHEN
T. conica EHRENBERG
Lagena sp. (n. sp.)
Bradyina nautiliformis v. MÖLLER
B. cf. *rotula* v. MÖLLER
Staffella sphaeroidea (v. MÖLLER)
S. confusa LEE and CHEN
Ozawainella angulata (COLANI)
Fusulinella sp.
Fusiella cf. *paradoxa* LEE and CHEN
Fusulina konnoi (OZAWA)

Cephalopoda
Remelleoceras subquadrangulare GRABAU
R. grabaui YIN
Pleuronautilus sp.

Brachiopoda
Productus cf. *gruenewaldti* KROTOW
Schllwienella kweichouensis GRABAU
Marginifera sp.
Spiriferina sp.

Bryozoa
Fenestella sp.

Trilobita
Humilogriffithides someyai ENDŌ

Many fossils of gastropods, corals and crinoids were also found. However, since their preservation was very poor, identification was impossible. From the shale at Lao-huan-tzu-kou, the writer collected *Lepidodendron* sp. in association with fossils of cephalopods, brachiopods, bryozoans and trilobites.

b. Takang Series

The type locality of this series is Ta-kang-ling, Te-chang-tzu. This series is the main coal-bearing formation in Tung-pien-tao. It is composed mainly of gray white coarse-grained sandstones, often with shale, coal and fire-clay; its total thickness attains about 70 m.

An unconformity is found at the base of this series;[45,52] the present series rests in parallel unconformity on the Ordovician limestone, without fault or thrust, north of Te-chang-tzu, and the Penhsi Series is lacking between these two formations.

In this series, well preserved plant fossils are often found in the coaly shales which accompany the important coal seams. They are listed in Table 5.

Referring to the fossils listed above, the Takang Series may be contemporaneous with the Liutang Series of the Tai-tzu-ho district, and may therefore be Lower Permian (Lower Rotliegende) in age.

In connection with this conclusion, an important question in the geologic history of Manchuria is whether or not the Huangchi Series, situated between the Penhsi and Liutang Series in South Manchuria, is completely lacking in this area. It is impossible to discuss this problem in detail until more precise stratigraphic data and fossils are obtained. Hence, it would be wise to avoid using the same series names as those of South Manchuria in this district. The writer suggests using the name Takang Series, taking it as equivalent to the whole or part of the Jido Series in Korea and the Yuehmenkou Series in Shan-hsi.

Table 5. List of Plant Fossils from the Takang Series.
(○ indicates the presence of many individuals)

	Specific name \ Locality	Lao-huan-tzu-kou	Hsiao-tung-kou	Wu-tao-chiang	Te-chang-tzu
	Annularia orientalis KAWASAKI	×			
	Sphenophyllum oblongifolium (G. et K.)	×	•	•	×
○	*Sph. emarginatum* (BRONGN)	×			
	Sph. cf. *Thonii* MAHR	•	×		
○	*Neuropteris* cf. *gleichenoides* (STUR.)	×	×	×	×
	Pecopteris sp.	•	•	•	×
○	*Lepidodendron molle* JONGM. et. GOT.	•	×	•	×
○	*L. oculis-felis* (ABB.)	×	•	•	×
	L. Yabei KOIWAI	×			
	L. cf. *orientale* KOIWAI	×			
	L. sp.	×	×		
○	*Stigmaria asiatica* JONGM. et. GOT.	×	×	×	×
○	*Cordaites Schenkii* HALLE	×	×	×	×
○	*Cordaicarpus cordai* GEIN. forma *elongata* J. et G.	•	×	×	×
	C. sp.	•	•	×	

c. Techang series

The type locality is Te-chang-tzu. The series mainly composed of ochre sandstone, with ochre shale in the upper part. Its total thickness may attain more than 300 m. At the base of this series, hard, ochre sandstone, several to seventy cm in

thickness and with varying amounts of hematite is developed and serves as convenient index bed field work.

No fossils were collected from the Techang Series, so its geological age cannot be discussed in detail. However, there is no doubt that this series is equivalent to the Tsaichia Series of the Tai-tzu-ho district.

C. Chin-chou and Je-ho districts

The Permian System of the so-called South Manchurian type is extensively distributed in the Chin-chou and Jeho districts. Since coal and fire-clay are intercalated within this system, it has been a subject of interest to geologists for many years. Important localities are Hung-lo-hsien (Fig. 9), Yang-chia-chang-tzu (Fig. 10), and Nan-piao in the western part of the former Chinchou province, and Yang-shu-kou, Pao-kuo-tu, Wu-tao-ling, Sung-shu-tai, and Hsing-lung coal fields in Jeho province.

A comparison between the writer's[27] results and those of Toshiji TAKAHASHI[43] and Li-hsu CHANG[3,4] is shown in Table 6.

Table 6. Correlation Table of the Permian System West of Chin-chou.

NODA (1940)	TAKAHASHI (1944)		CHANG (1944)
Hamashan Series	Hsingcheng Series		Hungla Series Fulungshan Series
Hunglohsien Series	Upper	Chinchou Series	Sanchiatzu Series
	Lower		Nanpiao Series
Ordovician limestone	Ordovician limestone		Ordovician limestone

a. Hunglohsien Series

The writer's Hunglohsien Series comprises the coal-measures which rest unconformably on the Ordovician limestone. It consists of sandstone, shale, conglomerate, coal and fire-clay, and, rarely, lenticular limestone. (see Fig. 3 & fig. 9).

Abundant plant fossils are collected from the coaly shale which is associated with coal in this series in the Hung-lo-hsien, Yang-chia-chang-tzu and Nan-piao coal fields. The main species, as far as known to date, are summarized in Table 7. From these fossils, it is evident that the Hunglohsien Series is equivalent to the Huangchi and Liutant Series of the Tai-tzu-ho district of South Manchuria.

A thin limestone layer is sometimes intercalated in the Hunglohsien Series, and it is especially well developed in the western part of the Yang-chia-chang-tzu coal field. No fossils were found in the limestone. However, the writer collected the following fossils from the black shale in the middle part of this series on the eastern slope of Ping-tien-shan, about 10 km south of Yang-chia-chang-tzu; these

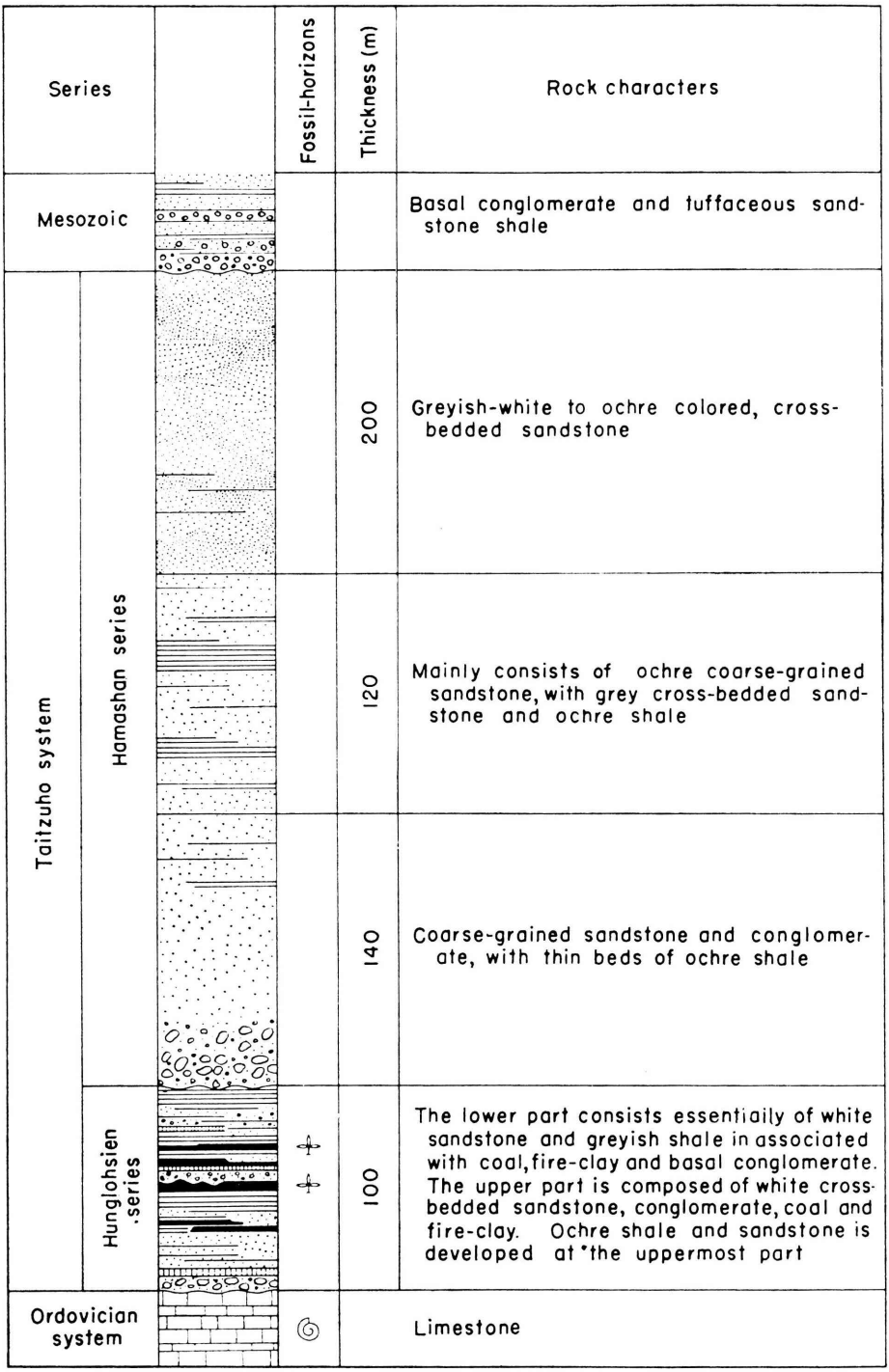

Fig. 3. Geologic Columnar Section of the Hung-lo-hsien Coal Field.

Table 7. List of Plant Fossils in the Hunglohsien Series.

Specific name \ Series and collector	Hunglohsien Series (Noda)	Chinchou Series (Takahashi)		Nanpiao Series (Chang)	Sanchiatzu Series (Chang)
		Lower	Upper		
Calamites Suckowi (Brongn.)	×	•	×	•	×
C. cf. *Cisti* Br.	•	•	×	•	×
Annularia macronata Schenk	×				
A. orientalis Kawasaki	×	•	•	•	×
A. gracilescens Halle	•	•	×		
A. ensifolius Halle	•	•	×		
A. cf. *stellata* (Schloth.)	•	•	•	•	×
Lobatannularia sinensis (Halle)	×	•	•	•	×
Macrostachia sp.	×				
Sphenophyllum orientalis Kaw.	×	•	•	•	×
Sph. oblongifolium (Germ. et Kadlf.)	×	•	•	•	×
Sph. verticillatum (Schloth.)	•	•	×		
Sph. emarginatum Br.	•	×	•	×	×
Sph. cf. *Thonii* Mahr	•	•	•	•	×
Sphenopteris Gothanii Halle	×				
Sph. tenuis Halle	•	•	•	•	×
Pecopteris polymorpha Br.	•	•	×	×	
P. Wongii Halle	×				
P. orientalis (Schenk)	•	•	•	•	×
P. candolleana Br.	•	•	×		
P. Anderssonii Halle	•	×			
P. arcuata Halle	•	•	•	×	
Cladophlebis Nystroemii Halle	×	•	•	•	×
Alethopteris ascendens Halle	×	×			
A. Norinii Halle	•	•	•	•	×
Emplectopteris triangularis Halle	×	•	×		
Emplectopteridum alatum Kaw.	×				
Callipteridium koraiense (Tokunaga)	•	•	×		
Neuropteris flexuosa Br.	×				
N. wutaolingensis Matsuzawa	×				
N. auricullata Br.	•	•	×		
Neuropteridium cf. *coreanicum* Kaw.	•	•	×		
Taeniopteris multinervis Weiss	•	•	•	•	×

Table 7. (Continued)

Specific name \ Series and collector	Hunglohsien Series (Noda)	Chinchou Series (Takahashi)		Nanpiao Series (Chang)	Sanchiatzu Series (Chang)
		Lower	Upper		
T. sp.	×	•	×		
Lepidodendron oculus-felis (Abb.)	•	•	•	×	
L. Gaudryi Renault	•	•	•	×	
L. orientale Koiwai	•	×			
Stigmaria ficoides (Sternb.)	×	•	×	×	×
Pterophyllum daihoensis Kaw.	•	•	•	•	×
Cordaites principalis (Germ.)	×	×	×	•	×
C. Schenkii Halle	×	×	×	×	×
Tingia elegans Konno	•	•	•	•	×
T. Hamaguchii Konno	•	•	•	•	×
T. ? carbonica (Schenk)	•	•	×	•	×
Tingiostachya tetralocularis Kon.	•	•	•	•	×
Astrocuplites acuminatus Halle	•	•	•	•	×
Cornucarpus sp.	×				
Samalopsis sp.	×	•	•	•	×
Cordaicarpus sp.	×	•	•	•	×
Trigonocarpus? Norinii Halle	×				
Largenospermum sp.	•	•	×		
Calpolithus sp.	•	×			

fossils are characteristic of the Taiyuan Series in North China and the Jisu Honguer limestone in Mongolia.

Brachiopoda

Chonetes cf. *latesinuata* Schell.

Productus taiyuanfuensis Grabau.

Streptorhynchus kaizeri Schell.

Pelecypoda

Sanguinolites cf. *olseni* Grabau.

Bryozoa

Genus and species indet.

Later, Takahashi treated this formation as the lower part of the Chinhsi Series, and added *Productus* cf. *gruenewaldti* Krotow and *Squamularia* sp. to the above list. The stratum from which these fossils were collected is in the middle part of the

Hunglohsien Series. It is doubtful whether the Penhsi Series is developed in this district.

b. Hamashan Series

The type locality is Ha-ma-shan Hill at the eastern end of the Hung-lo-hsien coal field (Fig. 9). It consists essentially of white and ochre coarse sandstone and ochre shale, the latter predominating in the middle part. Conglomerate is developed at its base and rests in parallel unconformity on the Hunglohsien Series.

The total thickness of this series is estimated respectively to be about 460 m, 1,200 m and 250 m in the Hung-lo-hsien and Yang-chia-chang-tzu coal fields and near Wei-tzu-kou in the Nan-piao coal field.

Formerly, the age of the Hamashan Series was assigned to Permo-Triassic or Triassic (?)[43,44]. However, since the writer collected *Calamites Suckowi* (BRONGN.), *Stigmaria ficoides* (STERNB.) and *Samaropsis* sp. from the coaly shale in the upper coal measures of this series at Shang-fu-erh-kou, Hsi-kou, south of Yang-chia-chang-tzu, it is concluded that this series still belongs to the Permian Period.

The Hamashan Series is overlain in parallel unconformity by thick basal conglomerate of the Mesozoic Era in the Hunglohsien and Nan-piao coal fields.

2. Special description

A. Tai-tzu-ho district

a. Yen-tai coal field

The Yen-tai coal field (Fig. 5) is located about 15 km east of Yen-tai Station on the Chung-chang Railroad (the main line of the former South Manchurian Railway) where the mountain lands open into the great Manchurian plain. The coal field is about 7 km N-S and 1–2.5 km E-W; a few rolling hills are found in the area.

In the Penhsi Series, ochre shales and sandstones about 50 m thick are developed in the lower half, while a complex of sandstones and shales with lenticular limestones, about 70 m thick, constitutes the upper half. Three beds of fire-clay are intercalated in this series, equivalent respectively to SAKAMOTO's E, F and G beds in descending order. These fire-clays are dark gray to gray-white and some of them are moderately good in both quantity and quality.

The Huangchi Series attains about 70 m in thickness; conglomerate to coarse sandstone is generally developed at the base where fire-clay bed D is distributed. This series is composed essentially of dark gray shales and coaly shales. Its lower part contains the Shang-chieh, Erh-chieh and San-chieh coal-beds, as well as several beds of semi-anthrathite or high grade bituminous coals called the "lower coal seam group; the upper part often includes sandstones and sandy shales.

The thickness of the Liutang Series is estimated to be about 170 m. Coal seams, inclusive of the Ta-tsao coal bed, are developed in its lower part. The middle to upper part consists essentially of blue-gray sandstone that turns yellow when weathered, often intercalated by thin beds of variegated shale, arenaceous shale and coal.

The fire-clay beds C, B and A are intercalated within the middle and upper part of this series, bed A, which is distributed in the vicinities of Pan-tao-ling, Tzu-erh-shan and Tsai-chia-shan, constitutes an especially good aluminous shale, and was formerly worked at Pan-tao-ling and Tzu-erh-shan.

From the standpoint of geological structure, this coal field constitutes a syncline which stretches from about north-northeast to south-southwest and is interrupted once in the vicinity of Ta-yu-kou. The uppermost part of the Taitzuho System in this coal field crops out on the eastern slope of Tzu-erh-shan and forms a dish-shaped structure. The average inclinations of both limbs of this synclinal structure are estimated to be 20°–30°. A great fault runs north-south at the center of this dish-shaped basin, where denudation is vigorous at present, and alluvium is thick. Therefore, the remaining quantity of fire-clay is very small.

b. Pen-hsi-hu coal field

The Taitzuho System in this coal field forms a truncated isosceles triangle; its upper and lower rim and diagonal lines are estimated respectively to be 3.6, 6.1 and 4.8 km long; its upper rim trends southwestward. The system is also distributed in a narrow belt along the western diagonal line, which stretches about 4.2 km to Lin-chia-wei-tzu at the south end. This coal field is the best area of distribution and development of the Taitzuho System in South Manchuria. Good semi-anthracite and high-grade bituminous coals are yielded.

The Penhsi Series crops out monoclinally along the north foot of a ridge which stretches from Ming-shan-kou on the east to Hsin-tung-kou on the west. It strikes almost east-west or NW-SE and dips 20°–30° toward the south. The total thickness is estimated to be about 120 m. It consists essentially of shale, sandstone and limestone. Two workable fire-clay beds are found in some areas in the lower part.

Limestone occurs mainly in the upper part of this series and is mostly lenticular.

The Huangchi Series consists of sandstone, shale, and coal; fire-clay bed D is intercalated in the lower part. The total thickness is estimated to be about 70 m. There are eight beds of coal belonging to the so-called lower coal group, which swell and pinch in places. The following five coal beds are workable.

I-chieh bed	0.6–1.8 m thick
Erh-chieh bed	2.4–2.7 ,,
San-chieh bed	0.6–1.0 ,,
Ssu-chieh bed	0.6–1.0 ,,
Wu-chieh bed	1.0–1.2 ,,

The thickness of the Liutang Series is estimated to be about 170 m. The series consists mainly of sandstone, shale and coal. There are about ten coal beds that are especially well developed in the lower part. The following three beds are workable and constitute the so-called upper coal group (in descending order):

Pao-cha bed	0.6–2.4 m thick
Hsiang-tuan bed	0.6–2.7 ,,
Chou-cha bed	0 –1.0 ,,

The coal is, in general, short flame, with a heating value of approximately 7,300 cal. and a strong caking capacity. This coal is therefore most suitable for manufacturing coke for iron smelting. The Pao-cha and Chou-cha beds are especially low in phosphorus and are mostly used for manufacturing low phosphorus cokes. Shales of the lower part of this series are black or dark brown; in the upper part they often become ochre colored, and fire-clay bed Ao is developed in the uppermost part.

The Tsaichia Series crops out typically on the southern slope of a ridge which stretches from south of the electric power house via Okura Shan to Ma-i-tsun-kou and on the northern slope of a hill south of Pao-chia-wa-tzu. Part of this series is rather extensively distributed between San-chia-tzu and Ho-tou-kou along the western rim of this district.

Let us now glance at the geologic structure of this coal field.

In the vicinity of Pen-hsi-hu and Miyanohara, the land forms a hilly basin surrounded by higher ridges. The Taitzuho System, the Miyanohara Group and the Kabutoyama andesite group are the principal formations exposed in this basin. The Tai-tzu Ho river runs from the northeastern corner to the southwestern corner across the basin. The hills surrounding the basin are composed of older Paleozoic strata. The Taitzuho System and the Miyanohara Group in the basin are in fault contact with these older Paleozoic strata, except for the northern side. Therefore this is a large structural basin.

c. Niu-hsin-tai coal field

The Niu-hsin-tai coal field is about 15 km upstream from Pen-hsi-hu (see Fig. 7). The Penhsi Series crops out extensively along the outer margin of this coal field, except in the alluvial plain to the northwest, and serves as the basement of the Permian coal measures. Limestone conglomerate of unknown age is developed between the Penhsi and Ssuyen Series in this coal field. Its development is especially remarkable in the south and southeastern parts, and its thickness is estimated at about 20 m in the vicinity of Hung-lien-kou.

The Penhsi Series is a complex of shale, sandstone and limestone, and is about 20 m thick. Thick development of ochre shales in the lower part and the presence of more limestone beds within this series are the outstanding features as compared with the Yen-tai and Pen-hsi-hu coal fields. Nodular limonite ore is contained in the basal part and was formerly mined east of Wang-kuang-kou. Fire-clay bed G occurs approximately in the same horizon as this limonite ore and sporadically contains very good aluminous shales.

The Huangchi Series is distributed in a relatively low hilly zone from Lao-kung-la-tzu via Wan-kuang-kou to Hung-lien-kou, and dips 20°–30° towards the southwest. It crops out at the foot of steep hills which consist of Ordovician Ssuyen limestone in the vicinities of Hsia-niu-hsin-tai and Hsiao-nan-kou, where it rests in parallel unconformity on the Penhsi Series and dips steeply towards the north. The upper part shows a gentle inclination of 15°–30° interrupted at one point by a strike fault. The Huangchi Series crops out three times from two north-south

faults on a hill south of Hung-lien-kou. The coal in this series was formerly mined at random throughout the area, but the coal seams are thinner, in general, than those of the Liutang Series.

The Liutang Series is well exposed on the eastern slopes of Lang-tung Shan and Wu-hsing-pai-tzu Shan, in the eastern part of Hsia-niu-hsin-tai as well as in the vicinities of Hsiao-nan-kou and Lao-mei-tung. The coal seams in the lower part of this series are the most important resources in the Niu-hsin-tai coal field. A somewhat generalized profile of bed A at Wu-hsing-pai-tzu Shan is as follows:

Hanging wall, sandstone

Coal and coaly shale	0.05–0.15	m thick
Black clay	2.00	,,
Coal and coaly shale	0.20–0.40	,,
Aluminous shale	2.00	,,
Gray clay	1.50	,,
Ochre and gray coarse clay	2.00	,,

Foot wall, sandstone

The Tsaicha Series is well distributed on the western slopes of Lang-tung Shan and Wu-hsing-pai-tzu Shan as well as at Sung-shu-pai; it always dips 20°–30° towards Hsia-niu-hsin-tai.

The geologic structure of this coal field, including the surrounding hills of the older Paleozoic and Sinian Systems, is characterized by a great synclinal structure whose axis runs from northwest to southeast. A divide south of Hung-lien-kou approximately corresponds to the synclinal axis. The dip of the strata is very gentle and stratification near this axis is nearly horizontal; the dip is gentler in the northeastern limb than in the southwestern. A great fault which is traceable from Pen-hsi-hu extends along the course of the Tai-tzu Ho; this fault line not only bounds the northwestern rim of this coal field under the alluvial plain but also cuts the synclinal structure. Thus the geology on the left side of the Tai-tzu Ho is contrasted with more complicated Paleozoic geology on its right side.

d. Hsiao-shih coal field

The Hsiao-shih coal field is located 46 km east of Miyanohara on the Hsi-kan line. The Penhsi Series is distributed extensively in the vicinity of Miao-kou, west of Hsiao-shih Station, east of Chang-chia-pu-tzu, Kan-chang-kou, Yuan-chia-pu-tzu, Li-chia-pu-tzu, Ma-chia-chuang-tzu and others. Six limestone beds are contained in this series in the neighborhood of Miao-kou. Though two or three coal beds are intercalated, they are too thin to be workable. Aluminous shales are sometimes contained within fire-clay bed G.

The area of distribution of the Permian System is divided approximately into the north and south districts. The Permian System west and east of Hsiao-shih is included in the north district while that in the south between Kan-chang-kou and Yuan-chia-wo-peng belongs to the south district. In both districts, the middle part of the Tsaichia System approximately bounds the upper limit of the Taitzuho System in the Hsiao-shih coal field. A synclinal structure in the north district has

its axis trending approximately from west-northwest to east-southeast, while in the south district the structure is monoclinal, striking approximately east-west and dipping towards the south. The southernmost boundary of this area contacts granitic porphyry of a later intrusion.

An isolated exposure of the Taitzuho System is found in the neighborhood of Chuan-shui Station, where the system forms a synclinal structure whose axis runs approximately east-west. Since the Tai-tzu Ho flows through the central part, most of this area is covered by alluvial deposits. However, the lower parts of the Penhsi Series crop out in both the north and south limbs and fire-clay bed G is traceable.

e. Tien-shih-fu coal field

The Tien-shih-fu coal field is located 38 km east of Hsiao-shih along the Hsi-kan line. Permian and Triassic coal measures are developed in this coal field. Since it has many hills, and the faults are remarkably developed, its structure is complicated. However, the Penhsi Series of the Taitzuho System crops out in the vicinities of Chuan-chia-pu-tzu and Kung-chia-pu-tzu as well as north of Chang-chia-pu-tzu. It consists of ochre-colored formations generally intercalated with one to three beds of grayish-white limestone.

The Permian coal measures are distributed mainly in the vicinities of Kung-chia-pu-tzu and Chuan-chia-pu-tzu, west of Ta-pu, as well as in a north-south belt along the eastern foot of the Pa-pan-ling range, north of Wang-chia-pu-tzu; part of it is also developed sporadically at the eastern foot of Tieh-cha Shan and in Ying-wu-pei.

The stratigraphic sequence and thickness of each series approximately coincide with those of the Pen-hsi-hu field. The sandstone in the middle part of the Tsai-chia Series is developed as the uppermost stratum of this coal field. Good coal seams are intercalated within the Huangchi and Liutang Series.

B. Southern district of Liao-tung Peninsula

a. Fu-chou (Wu-hu-tsui) coal field

The Fu-chou coal field is in Fu Hsien, Liao-ning Province. It is located along Fu-chou Bay at the mouth of Ya-tang Bay, about 50 km southwest of Wa-fang-tien station (see Fig. 8). This coal field is the type locality of the southern Liao-tung type of the Taitzuho system, and is well known for its good anthracite and fire-clay. A stratigraphic sequence ranging from the base of the Taitzuho System upwards to the middle part of the Liutang Series is developed.

The Penhsi Series is well distributed in the marginal parts of this coal field as the basement of the Permian coal measures; its total thickness is estimated to be about 90 m. The lower and upper parts of this series are characterized by ochre shale and ochre sandstone, the color becoming darker in the lower part. There is often also a splendid deep blue color due to the presence of ferric shale. Fire-clay corresponding to bed G of the Tai-tzu-ho district is always intercalated in this ochre shale, and is worked at San-ling-shan and Tao-shan as good, hard stone

clay. A thin bed of powdery coal associated with this clay bed as its hanging wall is sometimes developed.

Throughout the coal field, good fire-clay beds are distributed at the base of the Yatang Series and are subdivided into the upper, middle and lower beds from the standpoint of mining. Pyritiferous limestone pebbles which may have been derived from the Penhsi Series are abundant in the basal part of the Yatang Series, resting on the erosion surface of the Penhsi Series.

The Liutang Series is developed in a syncline with axis trending WNW–ESE, south of Fei-chia-tun. Since almost all of this series is concealed under a saline marshy plain its complete sequence is unknown. The north limb of this synclinal structure and the basal part of the Liutang Series are barely traceable at Hsi-piao, Fei-chia-tun and in a valley east of the old office of the former colliery. However, judging from observations of a mine interior and the boring data, it is probable that almost the whole sequence of this series is preserved except for the upper part which was more or less eroded out. A good anthracite bed, called the upper coal seam, is developed in this series and has been mined for many years.

The Fu-chou coal field is surrounded by Ordovician limestone and forms a great structural basin. Investigating the structure of this coal field in detail, one can recognize two synclines and one anticline. The axis of one syncline stretches from WNW to ESE between Lo-chia-shan and Ting-chia-tun and the other, running NW-SE, is found near Hsiao-li-chia-tun, the northernmost village in this coal field, and Kang-yao. One anticline is located south of Li-chia-tun between these two synclines. These structures control the distribution of the Taitzuho System of this coal field. The Hsiao-li-chia-tun—Kang-yao synclinal axis coincides with the Lo-chia-tun—Ting-chia-tun axis north of Pai-chia-tun, and forms a Y-shaped synclinal structure in the coal field, which has many faults and strong denudation. Saline marshes and low rolling hills are scattered throughout the district. Black chert in the middle part of the Yatang Series constitutes the tops of almost all these rolling hills. Since the faults and folds are quite remarkable, as at San-ling-shan and Tao-shan, the strata are usually steeply inclined.

b. Tiao-hu-chu

The Tiao-hu-chu clay quarry is located on the south coast of Ya-tang Bay, opposite the Fu-chou coal field on the north coast, about 15 km west of Erh-shih-li-tai Station in Liao-ning Province. Fire-clay in the ochre shale in the lower part of the Penhsi Series crops out in a small area commonly called the Chi-ting-shan Mine, on the coast which is covered at high tide. In view of its geological structure the area seems to be the southwestern limb of a great syncline which runs towards NW—SE. The Taitzuho System rests in parallel unconformity on the Ordovician limestone, and is covered unconformably by loess deposits. The stratigraphic sequence of the Taitzuho System in this area is as follows, in ascending order:

Ochre shale	about 30 m thick
Fire clay bed G	,, 1 m
Ochre shale	,, 8 m

Alternation of yellowish-gray sandstone and shale	more than 30 m

This succession constitutes the lower part of the Pen-hsi Series.

c. Chien-shih-hui-yao-tun area

The Taitzuho System crops out in a small area in the Ordovician limestone, on hilly land north of Chien-shih-hui-yao-tun and Yao-chia-tao, about 10 km northwest from Chin-chou Station along Chin-chou Bay. Though the outcrops in this area are generally poor and the geological structure is relatively complicated by many faults, the stratigraphic sequences coincide with those of the Fu-chou coal field. Hence, a geological survey of this area is relatively simple. The formations have a monoclinal structure dipping towards the north. The east-west strike prolongation is about 3 km. Here the Taitzuho System consists of the Penhsi Series associated with the lower part of the Ya-tang Series.

d. Tung-chia-kou

Tung-chia-kou is situated along a small bay, about 16 km east of Chin-chou, facing the Yellow Sea. Since small quantities of coal and aluminous shale have been yielded for many years, it is a well-known place. The Taitzuho system is distributed in a northwest-southeast long narrow belt of low rolling hills and at the foot of hills surrounded by older Paleozoic strata. The area is divided in two by the alluvial deposits of the Tung-ta Ho. Natives call the coal field west of the Tung-ta Ho, Hsi-yao and the coal field on the east Tung-yao.

The Taitzuho System, ranging from its base upwards to the upper part of the Yatang Series is exposed.

C. Hun-Chiang district

The Taitzuho System in the so-called Tung-pien-tao area is extensively distributed along the Hun-chiang, in the Sung-shu-chen and Wan-kou area (the Sung-wan coal field), and yields much good coal, especially caking coal, and fire-clay. Though the formations are very important and interesting from both the scientific and economic standpoint, the stratigraphical and paleontological reports of this district are relatively scanty. The writer surveyed the Taitzuho System in Tieh-chang-tzu, Wu-tao-chiang, Ta-tung-kou and Lao-huan-tzu-kou along the Hun Chiang river with the following results.

The Penhsi Series is generally about 100 m thick, but attains 270 m in Ta-tung-kou and thins out completely north of Tieh-chang-tzu. Though several thin seams of coal are intercalated throughout, usually none are workable.

It is especially noticeable that a basal conglomerate, 1–2.5 m thick, is developed at the basal part in the vicinities of Lao-huan-tzu-kou, Ta-tung-kou and in a valley of the Wu-tao-chiang, Mo-ku-yuan-tzu. The pebbles are water-worn quartzite ranging in size from a fingertip to a hen's egg, rarely to a man's head. However, these pebbles are compressed by later strong crustal movements.

One or two, or sometimes three, workable coal seams are found in the middle part of the Takang Series. However, they show swelling and pinching and form

so-called pockets. The thickest coal seam at the open mine in Li-shu-kou, Wu-tao-chiang is estimated to be more than 20 m. The coals are generally high-grade bituminous or semi-anthracite and most of them are powdery and highly caking. Therefore, the coals are suitable for manufacturing coke.

D. Chinchou-Jeho district

a. Hung-lo-hsien coal field

Hung-lo-hsien is a town located about 25 km west of Chin-chou. The Permian System is distributed in an area, 6 km east-west and 1.5–2 km north-south, and west of this town (see Fig. 9). Though some sporadic disturbances are noticed, the formations strike generally east-west and dip 20°–40° towards the north. The formations, showing a monoclinal structure, rest on the Ordovician limestone and are overlain unconformably by Mesozoic strata. In the vicinity of Tung-ta-ling, the western end of this coal field, the Permian System forms a syncline, its axis striking north-south and dipping about 30° towards the east.

Several seams of workable coal are interbedded in the Hunglohsien Series and were formerly worked at random.

Coal seams and fire-clay beds are especially well-developed in the eastern part of this coal field, but they, together with the Hunglohsien Series, become very thin westward from Chien-pan-chuang.

The Hamashan Series is characterized by cross-bedded, ochre sandstone; its lower part is often associated with the same colored shale and also includes cross-bedded, gray to white, coarse-grained sandstone and conglomerate. These rocks are resistant to erosion and form a continuous line of hills which stretch east-west in this coal field.

The Mesozoic formation, resting unconformably on the Hamashan Series, is distributed extensively along the northern margin of this coal field, and consists mainly of so-called volcanic strata; consequently, it has no fossils.

All the formations are sporadically disturbed somewhat by several faults in some places of this district. Of these faults, one that runs north-south, passing through Kao-shan-tun, is particularly noticeable. The Hunglohsien Series and the underlying Ordovician limestone, cut by this fault at approximately right angles are seen to extend from the southern foot of Ha-ma Shan, and disappear at the eastern foot of Nan Shan.

b. Yang-chia-chang-tzu coal field

Yang-chia-chang-tzu coal field (Fig. 10) is located about 35 km northwest of Chin-hsi where the well-known Yang-chia-chang-tzu Mine Office of the former Manchuria Mining Co. is situated.

Two imperfect large synclinal structures are recognizable in this area. One of them passes the vicinity of Fu-erh-kou with an east-west axis, while the other, with northeast-southwest axis, passes Pai-miao-tzu and Ssu-ssu Shan on the western margin of this area. The north limb of the former dips about 40°–70° to the south. Due to the intrusion of the Tapeiling granite, ore deposits of galena, zincblende,

molybdenite, magnetite, etc., are developed mainly in the Cambrian limestone.

Sandstone at the upper part of the Hamashan Series strikes east-west dips about 20° to the south in the vicinity of Pi-chia Shan. The south limb dips 20°–40° to the north. Strata ranging upward from the Sinian to the Hamashan Series, southwest of Ping-ting Shan are intruded by granite. Intrusion of monzonite is extensively noticed in an area between Shang-pein and Sung-shu-mao west of Pi-chia Shan. The synclinal structure of this area is remarkably deformed by the monzonite intrustion.

The Hunglohsien Series is developed best in an area between Pai-yang-mu-kou and Shang-pien to the west. The thickness of this series is estimated to be about 80 m in the vicinity of Hsia-hei-yu-kou, but it becomes much greater near Sung-shu-mao, locally exceeding 300 m.

Coal seams are intercalated in the middle and upper part of this series in the neighborhood of Hsia-hei-yu-kou. They range from 50 cm to almost 1 m in thickness, the thickest seams being in the upper layer. Only two of these 60–70 cm thick, have been developed.

Four beds of fire-clay are found in this series on a hill east of Yang-chia-chang-tzu, but all except the lowermost grade into shale or sandy shale.

The Hamashan Series of this area consists essentially of thick sandstone, and its upper limit is truncated by an east-west fault in the central part of a synclinal structure. The thickness of the series is estimated at about 1,200 m.

c. Nan-piao coal field

A village called Sha-kuo-tun 31 km northwest of Nu-erh-ho Station, is the center of the Nan-piao coal field. The northeast extension of the coal field reached Kao-li-ching-tzu via Ta-yao-kou and Chao-chia-tun, and as far as Erh-fo-miao in Chin-hsi Hsien and Kang-yao-kou in I Hsien; its southwest prolongation reaches west of Kang-yao-ling via Fu-lung-shan in Chin-hsi Hsien, Wei-tzu-kou and Tang-chin-kou in Chao-yang Hsien. Thus, this is a narrow Permian coal field, about 33 km in its total extension. In general, it shows a monoclinal structure, dipping to the northwest, and its extension along a strike is sometimes interrupted by the intrusion of andesite. This coal field is also disturbed by many faults and intruded by volcanic rocks. One to six workable coal seams are intercalated in the lower part of the Hunglohsien Series, while one to four thin seams, less than 1 m each, are found in the upper part. These coal seams always swell and pinch, often easily thinning out.

About three beds of fire-clay are interbedded in the Hunglohsien Series, the upper and lower one being relatively continuous and of good quality. Each bed is conformable with its hanging and foot walls. The correlation of these beds with those of the Tai-tzu-ho district has not yet been completely studied.

The Hamashan Series consists mainly of ochre, nonfossiliferous, coarse- grained sandstone with white, coarse-grained sandstone at its base where conglomerate is found occasionally.

The Mesozoic conglomerate and sandstone which contain large quantities of

sand and gravel of volcanic rocks are developed extensively throughout this coal field, and the Mesozoic formation rests unconformably on the Hamashan Series.

d. Yang-shu-kou coal field

The Yang-shu-kou coal field is situated about midway between Pei-piao and Chao-yang; it is about 10 km north of Nung-chia station on the Chin-ku line, and about 4 km directly south from the southwestern end of the Pei-piao coal field. Chao-chi LIN[16] divided the stratigraphic sequence in this area as shown in Table 8. According to his report, the formations ranging from the Sinian limestone to the Mengkuyingtzu shale were overturned, on the Tuchengtzu conglomerate to form a *klippe*. This klippe strikes N 40°–60° E and, since the Paleozoic strata consist of plastic shales, they are remarkably disturbed by extensive lateral pressure and have variable inclinations, being sometimes, even vertical, and pinch and swell extraordinarily.

Table 8. Geological Stratigraphic Sequence in the Vicinity of Yang-shu-kou (after LIN).

Mesozoic	Tuchengtzu conglomerate Mengkuyingtzu shale Hachihhai agglomerate Hochiakou tuff
Paleozoic	Permian coal seam Mantou shale
Pre-Cambrian	Basic intrusive sheet (olivine gabbro) Sinian limestone

Hiroshi OZAKI[40] collected *Cordaites* sp., *Sphenophyllum oblongifolium* (G. et K.), *Sph. emarginatum* BR., *Sph.* sp., *Sphenopteris* sp., and *Samaropsis* sp. from the debris near the entrance of the Tungyao mine in this coal field.

e. Vicinity of Pao-kuo-tu

The Permian System(?) is extensively distributed south of Pao-kuo-tu, about 80 km north of Pei-piao. According to MORITA and SAKAGUCHI[23], the geological setting of this area is as follows:

The formation strikes generally N 60° E, and its prolongation attains about 24 km. The following features are notable. (1) The formation seems to rest directly on the gneiss group, in between, lacking the fossiliferous Ssu-yen limestone of the Ordovician. (2) Five lenticular beds of limestone are found in the lower part, while the upper part consists of conglomerate, sandstone, shale and fire-clay in which three coal seams are intercalated. (3) Though the development of lenticular limestone is remarkable, fossils are rarely found; only one species each of coral and bryozoa, and a fragment of crinoid stem were collected. (4) More than thirteen limestone beds are counted, which is ascribed to the repeated appearance of the same strata due to disturbance.

f. Wu-tao-ling coal field

The Wu-tao-ling coal field is located 37 km directly southwest from Ling-Yuang, Jeho Province. This coal field is also midway along the road from Ling-yuan, via Cha-peng, Ta-chang-tzu and Chien-chang-ying-tzu, to the Kai-luan coal field in North China.

The Permian System is divided into two blocks by an approximately east-west fault which passes near Pei-ta-ling, and these blocks are displaced by about 400 m. The strike is roughly N-S and the dip is about 50° E. The north block sometimes shows a strike N 70° W and dip 20° NE. In the east, both the north and south blocks contact the Ordovician limestone which was thrust upon these blocks from the east. The Permian System of the south block consists chiefly of yellow sandstone, in association with brown shale, coal, coaly shale and conglomerate. This formation is distributed in a north-south trending narrow belt, 50–200 m in width, and disconformably covers the underlying Ordovician limestone.

Formerly, R. KONDO collected several plant fossils from the black to dark gray shale in this coal field, and of them *Lepidodendron oculis-felis* (ABB.) and *Neuropteris wutaotingensis* MATSUZAWA were described by MATSUZAWA[17].

g. Sung-shu-tai area

Sung-shu-tai is a town 16 km southeast of Ping-chuan, Jeho Province. The Permian System is distributed in an area from the north foot of Nan-ta-wa Shan to the north of Sung-shu-tai. The strike is NW or N 60° W and the dip is 30°–45° NE. The formation is divided into the upper, middle and lower groups by KAWADA.[9]

The lower group consists of conglomerate, sandstone and sandy shale. Hard fire-clay is interbedded at its base. The total thickness is 30–100 m.

The middle group consists of siliceous sandstone and conglomerate, intercalated with two coal seams. The total thickness is about 90 m.

The upper group is composed of an alternation of sandy shale and sandstone. Since the upper part of this group is covered by alluvial deposits, its total thickness is not estimated. However, the thickness of the exposed part is about 120 m.

h. Hsing-lung coal field

The Hsing-lung coal field is situated about 90 km south-southeast of Jeho. This coal field, with Ying-shou-ying-tzu as its center, is about 28 km east-west and 1–2 km north-south. The so-called Pei-ma-chuan-tzu, Lao-yeh-miao and Huo-shen-miao coal fields are included in this coal field.

The area is generally occupied by steep hills and the strata are remarkably disturbed, but the Permian System strikes generally east-west and dips towards the south. Along the southern margin of this coal field, the Ordovician limestone was thrust upon the Permian System, whereas along the northern margin, the Permian System rests in parallel unconformity on the Ordovician limestone and is overlain by the Lower Cretaceous System. Granite, porphyry and basalt intrude the Permian System.

Toshio KIHARA gave the name Liuho System to the Permian formations in this coal field and subdivided the stratigraphical sequence as in Table 9.

Table 9. Stratigraphic Sequence of the Liuho System in the Hsing-lung Coal Field.

Liuho System	Maoshan formation	Maoshan sandstone	more than 60 m thick
		Upper coal-bearing shale	5–15
		Fushan sandstone	15–30
		Middle coal-bearing shale	15–30
	Huangshenshan formation		80–120
	Lamakou formation		20–30
	Peishan formation	Lower coal-bearing shale	10–30
		Peishan conglomerate	10–40
	Chuanshihkou formation	Lowermost coal-bearing sandstone	15–50
		Basal conglomerate	15–30

A coal seam about 1 m thick is interbedded in the lower coal-bearing shale which is conformably overlain by a black shale of the Lamakou formation. The lowermost part of this black shale is calcareous, about 0.2–5.0 m thick, and has abundant marine fossil animals. KIHARA collected the following animal fossils which were identified by the present writer.

Bryozoa

Fenestella sp.

Brachiopods

Squamularia asiatica CHAO
Spiriferina cristata SCHELLW.
Orthotichia derbyi (WAAGEN)
Schellwienella sp.
Orthothetina sp.
Chonetes molleri TSCHERNYSCHEW
Ch. carbonifera KEYSERING
Waagenoconcha cf. *abichi* WAAGEN
Marginifera pusilla SCHLLW.
Productus taiyuanfuensis GRABAU
P. gruenewaldti KROTOW
P. cf. *volgensis* STUCK.
Linoproductus koninchianus (VERNEUIL)
Striatifera sp.

Cephalopods

Orthoceras sp.
Pleuronautilus sp.
Remeleoceras grabaui YIN

Gastropods

Bellerophon compressus GRABAU

B. cf. *jonerianus* DE KONINCK
Euphemus sp.
Euomphalus sp. (n. sp. ?)
Holopella trimorpha WAAGEN
Sphaerodoma avellanoides (DE KONINCK)
Soleniscus sp.

Pelecypods

Nuculopsis anthraconeiloides CHAO
Schizodus shansiensis CHAO
Sch. subquadratus GRABAU
Sanguinotites olseni GRABAU
Astartella adenticulata JAKOWLEN
Lima striatoplicata CHAO
Aviculopecten alternatoplicatus CHAO
Entolium aviculatum SWOLLOW
E. cf. *obtusum* GRABAU

From these fossils, it is clear that the Lamakou formation is correlated with the Taiyuan Series of North China. If this is true, it is problematical whether the Penhsi Series is developed in this coal field or not. Not only in this area but also in other areas throughout Chin-chou and Jeho districts, it was thought that the Penhsi Series is not developed. As mentioned above, no data to verify the presence of the Penhsi Series were available in this coal field. However, considering the fine development of the Penhsi Series, about 120 m thick, in the Kai-luan coal field not far from this coal field, the presence of the Chuanshihkou formation is very noticeable, as it is separated by an unconformity at the base of the Peishan formation according to KIHARA. The Huangshenshan formation yields *Lepidodendron,* while the Maoshan formation contains many plant fossils, identified by the writer as follows:

Calamites Suckowi (BRONGN.)
Annularia stellata (SCHLOTH.)
Sphenophyllum oblongifolium (GERM. et KAULF.)
Sph. Thonii MAHR
Sph. Thonii var. *minor* STERZEL
Pecopteris spp.
Cladophlebis Nystroemii HALLE
Alethopteris ascendens HALLE
Neuropteris flexuosa BRONGN.
Odontopteris subcrenulata (ROST)
Emplectopteris triangularis HALLE
Emplectopteridium alatum KAWASAKI
Protoblechrum Wongii HALLE
Taeniopteris sp.
Lepidodendron oculis-felis (ABB.)

Stigmaria ficoides (STERNB.)
Cordaites principalis (GERM.)
C. Schenkii HALLE
Tingia Hamaguchii KONNO

These plant fossils suggest an age equivalent to the Shanhsi Series of North China and the Liutang Series of South Manchuria.

III. The Carboniferous and Permian Systems in North Manchuria

1. General description

Neither the stratigraphic nor the paleontologic studies of North Manchuria are much advanced. It is noticeable that in lithology and palentology North Manchuria differs from South Manchuria and is rather similar to Siberia and Mongolia. The formations are mainly of marine deposits.

An apparent eastern prolongation of the Jisu Honguer formation of Mongolia described by A. W. GRABAU[5] is extensively distributed in the west of Ta-pan-shang in Jeho Province, in the vicinities of Lin-hsi and Tarim Nor, as well as in the Cha-ha-erh Province of Inner Mongolia.

LICENT and CHARDIN[15] gave the name Linhsi formation to a complex of green clayslate and conglomerate which is distributed in the vicinity of Lin-hsi, and they reported the presence of Permian fossils in a thin bed of limestone which is interbedded in this Linhsi formation. A description of these fossils has not yet been published, however.

Shigemitsu OKADA studied the geology of a hilly land north of the Dabus Nor basin, and collected many animal fossils there. He gave the name of Dabus Nor formation to the Upper Paleozoic rocks of this area.

According to OKADA, a north-south fault system predominates in the hilly land, and one fault divides the area into two blocks, east and west. However, both blocks generally strike N 80° E and dip 50°–60° to the south, and form a monoclinal structure. The western block lacks a basal part due to the intrusion of granite along the northern margin. Since the southern margin of the eastern block contacts the Pre-Cambrian formation(?) by a fault, the upper limit cannot be recognized. The formations constituting the eastern and western blocks are tentatively called the East and West formations. The stratigraphic relation between these formations needs more detailed studies in the future, but OKADA inferred from the lithology, fossils, and geologic structure, that the East formation is younger than the West formation. The stratigraphic sequence of each formation is given in Table 10 (X means fossiliferous).

Except for bed C_1, the conglomerate, sandstone and clayslate of each bed alternate and grade lithologically into one another. Consequently, the boundaries of each bed in Table 10 are not always distinct, especially in the East formation. The writer identified the following fossils from these two formations. Consequently,

Table 10. Stratigraphic Sequence of the Permian System in the Vicinity of Dabus Nor (after OKADA).

East formation		
f.	Graywacke, sandy clayslate	2,000 m+ thick
e.	Conglomerate, conglomeratic sandstone, clayslate(?), limestone (X)	1,200
d.	Graywacke, arkose sandstone, clayslate, limestone (X)	800
c.	Conglomerate, graywacke (X), arkose sandstone, sandy clayslate	1,000
b.	Graywacke, black clayslate	1,200
a.	Dark sandstone, sandy clayslate	1,000
West formation		
E_2.	Conglomerate, graywacke, arkose sandstone	2,000
E_1.	Conglomerate (X), graywacke (X), arkose sandstone, clayslate (X), limestone (X)	800
D.	Agglomerate	600
C_2.	Conglomerate, arkose sandstone, clayslate (X), limestone	100
C_1.	Conglomerate, conglomeratic sandstone	2,500
B.	Andesite	100
A_2.	Conglomerate, arkose sandstone, sandy clayslate (X), clayslate (X)	100
A_1.	Conglomerate, breccia, graywacke, clayslate (with a thin bed of limestone?)	1,500

there is no doubt that these formations correspond to the Jisu Honguer formation of Mongolia.

Arthropoda

Trilobita. Genus and species undetermined.

Bryozoa

Geinitzella collumnaris var. *tuberosa-sparsigemmata* GRABAU

Fenestella sp.

Brachiopods

Diellasma millepunctatum var. *mongolicum* GR.

D. jisuense GR.

Hustedia remota (EICHWALD)

Spiriferella kailhaviiformis FREDRICKS

S. salteri TCHERNYSCHEW

Neospirifer moosakhailensis DAVIDSON

N. fasciger (KEYSERLING)

Choristites trautscholdi (STUCKENBERG)

Martinia mongolica GR.

M. orbicularis GEMMELLARO

Uncinulus sp. (n. sp.)

Camalophoria superstes (VERNEUIL)

C. pordoniformis GR.

Orthotychia cf. *derbyi* (WAAGEN)

Enteletes obesa GR.

Chonetes sp. (n. sp.)
Schuchertella frechi HUANG
Schellwienella regina GR.
Derbya dupliciseptata GR.
D. cf. *hemisphaerica* WAAGEN
Meekella sp.
Cf. *Geyerella mongolica* GR.
Derbyella bureri GR.
Linoproductus lineatus (WAAG.)
L. cora (D'ORBIGNY)
Striatifera sp.
Echinochonchus fasciatus KUTORGA
Produceus cf. *porrectus* KUT.
Proboscidella cf. *leta* TSCHERN.
Thomasia sp.
Marginifera morrisi CHAO

Pelecypods
Schizodus sp.
Sanguinolites olseni GR.
Pseudomonotis (*Aviculomonotis*) *kazanensis* (VERNEUIL)
P. furcoplicatus GR.

Gastropods
Bellerophon jonesianus DE KONINCK
Luciella planoconvexa GR.
Naticopsis khoovensis WAAG.

Corals
Tetrapora syringoporoides YOU
Wentzelella sp.

Echinodermata
Crinoids

In North Manchuria, KOBAYASHI's[11,12] Solun formation (its age between post-Devonian and Permian) and the Hahai fauna (latter half of the Permian) are distributed.

According to Hajime YOSHIZAWA[44] and Hikoji MORITA,[22] metamorphosed sedimentary formations are sporadically distributed also throughout the Ta-hsing-an-ling area.

At this time, the problems of the Chilin and Touman formations are of special interest to us. As far as the present inferences are concerned, the Chilin formation is composed mainly of the Carboniferous System in association with a part of the Devonian System, while the Touman formation which is extensively distributed in Eastern Manchuria consists almost wholly of the Permian System. Therefore, it is reasonable to infer that these two systems were deposited in different marine basins. However, as will be mentioned in the following paragraph, if the same

strata or fossils as the Touman formation are found from the Chilin formation, that part would be inferred to be the westward transgressed sediment of the Touman formation and may need to be separated from the Chilin formation. Again, if the Permian System, which is related to the Mongolian geosyncline, e.g. the Permian System in the vicinity of Yu-chuan, were found from the Chilin formation in the future, it would be explained as the deposition of the eastern end of the latest transgression in the same geosyncline, and it would also have to be separated from the Chilin formation.

2. Special description

A. Chilin formation

The Chilin formation was named by Michio KAWADA[8] for a complex of hornfels, breccia and limestone which is extensively distributed in the vicinity of Chi-lin; its thickness is estimated to be 1,000–3,000 m. Though KAWADA grouped it under the so-called Permo-Carboniferous Period, he added that the Devonian or Silurian Periods may be associated with this formation.

As was expected, Devonian fossils and strata were found recently from a part of the Chilin formation in the vicinity of Erh-tao-kou in the suburbs of Chi-lin. It is anticipated that this stratigraphical relation will be investigated in the future.

Until the present time, the Chilin formation, which is distributed in the vicinity of Ming-cheng on the Shen-chi Line, was studied in the greatest detail. Shigemitsu OKADA[3] divided the Chilin formation in this locality into upper, middle and lower parts and each part was again subdivided into upper and lower subdivisions. The lower part of the lower formation (bed a) consists essentially of gray to black shale and clayslate with occasional thin beds of limestone containing corals and brachiopods.

The upper part of the lower formation (bed b) is composed of large lenticular limestone containing corals and crinoids, and is about 500 m thick. This formation often grades into saccharoidal limestone under the influence of granite.

The lower part of the middle formation (bed c) is composed mainly of dark gray clayslate which contains plant fossils and pelecypods (*Pecten* and others). Thin beds of limestone predominate as one moves upwards and are at last gradually transformed into the following bed d.

The upper part of the middle formation (bed d) is a thick limestone group, 2,000 m thick; it is generally gray to white and extensively distributed with a south-eastward prolongation from the vicinity of Ming-cheng station. Thin beds of black to ochre shale, pale greenish tuff and brecciated sandstone are interbedded in some parts of it. Corals and crinoids are yielded from the limestone.

The lower part of the upper formation (bed e) is black shale, and crops out only in the vicinity of Ma-tai-kou.

The upper part of the upper formation (bed f) is volcanic rocks and consists of agglomeratic porphyrite to plagio-liparite with a thin bed of white tuff. It grades sporadically into agglomerate and agglomeratic conglomerate.

Subsequently, Masao MINATO[19] recognized the five following fossil zones in both beds b and c of OKADA at a place between Lu-chuan-tzu and Lao-tao-kou.

1. *Dibunophyllum* zone. *Dibunophyllum* spp., *Clisaxophyllum* spp., *Palaeosmilia*? sp., *Carcinophyllum* sp., *Diphyphyllum* sp.

2. *Gigantella* cf. *latissimus* zone. *Gigantella* cf. *lattissimus* (SOWERBY), *G.* sp., *Endothyra* sp., *Siphonodendron irregulare asiatica* (YABE and HAYASAKA).

3. *Siphonodendron* zone. *Siphonodendron irregulare asiatica* (Y. et H.), *S.* sp.

4. *Auloclisia* zone. *Auloclisia* sp., *Caninia* sp., *Clisaxophyllum* sp., *Thysanophyllum*? sp.

5. *Lonsdaleia floriformis floriformis* zone. *Lonsdaleia floriformis floriformis* MARTIN, *Siphonodendron irregulare asiatica* (Y. et H.), *S.* sp.

He described these fossils and concluded that its age is the uppermost part of the Lower Carboniferous and is to be correlated with the Visean in Western Europe (*Dibunophyllum* zone), *Yuanophyllum* zone at the upper part of the Fengnin System in South China and the Onimaru series in Japan.

Hiroshi OZAKI[41] collected fossils of foraminifera from a limestone boulder in the vicinity of Nan-ti-tzu, north of Ming-cheng. From this boulder, the writer identified *Fusulinella* sp., *Ozawainella* sp., *Tetrataxis* cf. *conica* EHRENBERG and bryozoa and concluded that the age is Moscovian, i.e. that it can be correlated to the Penhsi series. According to OZAKI, the diameter of this boulder is about 1 m, and limestone similar to the boulder crops out on the slope of a northern hill near by. Therefore, it is clear that the boulder fell from this limestone outcrop.

OZAKI also collected fusulinids and crinoids from a limestone boulder which may have been derived from the limestone in dark-grayish hornfels, in the district northeast of Hsi-hsiao-ho-yen, Erh-tao-ho-tzu, Yung-chi Hsien, about 30 km north of the former locality. The writer identified *Schubertella obscure* LEE et CHEN from the boulder. Since the present species was first reported, from the Huanglung limestone in Central China, this boulder may be Moscovian in age, like the limestone at Nan-ti-tzu.

Thus, the Middle Carboniferous System may be developed sporadically in a rather extensive area in the vicinity of Yen-tung-shan. However, the detailed stratigraphic sequence of this system and the mutual stratigraphic relations between the system and the above-mentioned formation near Ming-cheng are not yet well understood.

As was seen from the above description, the group which was formerly treated as the Chi-lin formation consists essentially of the Carboniferous System in association with a part of the Devonian System. There is evidence for the presence of the Permian System, however, in *Pseudoschwagerina* sp. found by MINATO[21] in the vicinity of Ming-cheng. Thus, though the exact stratigraphic position is not yet recognized even to-day, the existence of the Permian System in the Chi-lin formation is gradually being confirmed at the present time. Hence, the so-called Chi-lin formation may range from the Devonian to the Permian and must be subdivided through further study. Only after this can the correlation and precise paleogeography be discussed in detail.

B. Touman formation

The Touman formation was named by Keiji HARIO for the Permian System in the vicinity of the Tou-man River. Later, M. MINATO[20] identified the following fossils, which were collected by Takumi NAGAO from clayslate-like chert at Shang-tsai-hsiu-tung, southwest of Kai-shan-tun, Ho-lung Hsien, Sung-chiang Province. MINATO concluded that the age of this formation is the upper part of the Middle Permian (Artinskian).

Fenestella spp.
Polypora manchoukuoensis MINATO
Acanthocladia (?) sp.
Batostomella (?) sp.
Waagenophyllum indicum (WAAGEN et WENTZEL)
Linoproductus lineatus (WAAG.)
Echinochonchus sp. nov. (?)
Spiriferina cristata SCHLOTHEIM
S. nasuta WAAG.
Spirifer sp.
Hustedia (?) sp.
Marginifera sp.
Aviculopecten sp.

Subsequently, the writer[33] surveyed the Touman formation, which is distributed in the vicinities of Kai-shan-tun and Sang-sam-bong, Hamgyeong bukdo on the bank opposite Manchuria and divided it into upper, middle and lower parts according to the lithic character. Of these, the lower and middle parts gradually intergrade.

The boundary was tentatively established as a line between the limestone and ochre rocks; the limestones of the lower part become relatively fewer and the ochre rocks of the middle part become more conspicuous near the boundary line, while the boundary between the middle and upper parts is comparatively distinct. The middle part is composed of many ochre rocks while the upper completely lacks ochre rocks and consists mainly of dark black rocks with a moderately thick conglomerate at its base. It is inferred that there is an unconformity between them, but this has not yet been confirmed.

The lower part of the Touman formation is extensively developed at Nei-yen-chih, Tsai-hsiu-ling, Nan-ta-feng and in the area east of Sang-sam-bong. Though its base is unknown, the thickness is estimated at more than 1,000 m. It consists essentially of clayslate, shale, sandstone and sandy hornfels with more than two beds of limestone. The limestone is dark gray in most cases and is sometimes altered white by metamorphism.

In the vicinity of Sekido, east of Sang-sam-bong, the general strike is north-south and the dip is steeply westward. Fossils listed in Table 11, especially the more advanced fusulinids, are abundant in the gray limestone, about 50 m thick, in the relatively lower part of the Lower Touman formation on a cliff in a valley

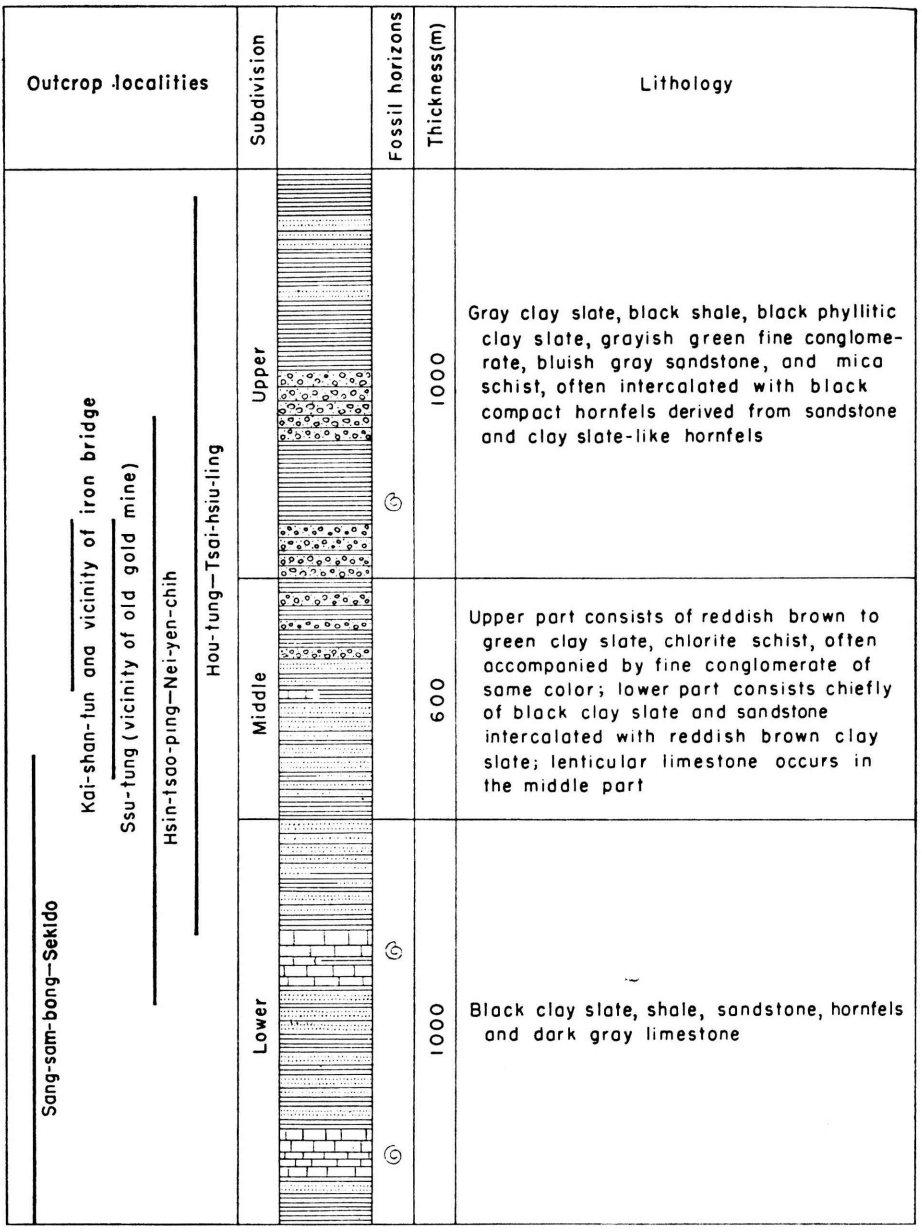

Fig. 4. Geologic Columnar Section of the Kai-shan-tun District.

about 4 km east of Sang-sam-bong Station.

The middle part of the Touman formation crops out most extensively in an area from Kai-shan-tun to the vicinity of the former office of the Ssu-tung mine and on the northern slope of Tsai-hsiu-ling; its thickness is estimated at about 600 m. Its lower part is composed mainly of black clayslate, green conglomerate and

sandstone, with one or two beds of ochre clayslate. Upwards, ochre clayslate and ochre conglomerate predominate and gray to grayish-green clayslate, conglomerate, and sandstone or green marl are associated with the ochre rocks.

Table 11. List of Fossils in the Touman Formation.

Fossils \ Locality		Lower			Upper
		Sekidō	Yao-shui-ssu	Tsai-hsiu-ling	Shang-tsai-hsiu-tung
Green algae	1. *Mizzia velebitana* SCHUBERT	×			
Foraminifera	2. *Tetrataxis* spp.	×			
	3. *Lunucammina? conica* LANGE	×			
	4. *Pachyphloia pediculus* LANGE	×			
	5. *P.* sp. (n. sp.)	×			
	6. *Lagena* sp.	×			
	7. *Staffella* sp. (n. sp.)	×			
	8. *Triticites* sp.	×	•	×	
	9. *Parafusulina imlayi* DUNBAR	×			
	10. *P. subextensa* CHEN	×			
	11. *P. lungtanensis* CHEN	×			
	12. *P.* cf. *constricta* CHEN	×			
	13. *P.* sp.	×			
	14. *Misellina* spp.	×			
	15. *Neoschwagerina* cf. *margarite* DEPRAT	×			
	16. *Yabeina hayasakai* OZAWA	×	×		
	17. *Y. shiraiwensis* OZAWA	×			
	18. *Sumatrina gemellaroi* SIRVESTRI	×			
	19. *Lepidolina* sp.	×			
Tetracoralla	20. *Wentzelella timorica* (GERTH)	•	•	×	
	21. *Waagenophyllum?* sp.	•	×		
Bryozoa	22. *Fenestella* sp.	•	•	•	×
	23. *Polypora?* sp.	•	•	•	×
Brachiopoda	24. *Chonetes* cf. *chonetoides* (CHAO)	•	•	•	×
	25. *Neospirifer* cf. *moosakhailensis* DAVIDSON	•	•	•	×
	26. *Spiriferella persarnae* GRABAU	•	•	•	×
	27. *Spiriferina* (*Tylotoma*) *cristata* SCHLOTH.	•	•	•	×
Pelecypoda	28. *Pseudomonotis* (*Aviculomonotis*) *kazanensis* (VERN.)	•	•	•	×
Crinoidea	29. Genus and species indet.	×	•	×	×

The upper part of the Touman formation is extensively distributed at Kai-shan-tun, Ssu-tung, Shang-tsai-hsiu-tung, Hou-tung, Shih-po-tung, Hsin-tsao-ping and in the western part of Hui-ching-chieh and its thickness is estimated to be more than 1,000 m. It consists mainly of gray clayslate, black phyllitic clayslate, grayish green small-grained conglomerate, bluish gray sandstone, and mica schist with occasional intercalating black hard compact sandy hornfels or clayslate-like hornfels.

At the base of the upper part, grayish green conglomerate, 50 m thick, is usually developed and is often intercalated with sandstone of the same color. Many of the marine fossils listed in Table 11, especially brachiopods and bryozoa, are yielded from the sandy hornfels just beyond this conglomerate at Shang-tsai-hsiu-tung. The fossils collected by the writer at Shang-tsai-hsiu-tung are approximately the same as those formerly reported by MINATO.[104]

The writer concluded that the total Touman formation in the vicinity represents the upper part of the Lower Permian on the basis of the fossils listed in Table 11, and that this formation is equivalent to the Leonald formation in the U.S.A., the upper part of the Artinskian in the U.S.S.R., the uppermost part of the Chihsia limestone in China and a part of the Maokou limestone. To settle the problem of what part of the Touman formation is exposed in this vicinity in relation to the Touman formation that is extensively distributed in Eastern Manchuria, northern Manchuria, and the U.S.S.R. will require further investigation of all formations.

Yenzo KONNO[13] collected many plant fossils from the conglomerate (containing pebbles of granite and granitic gneiss), 170 m thick, in the vicinity of Kai-shan-tun and inferred that its horizon is approximately the same as the marine fossiliferous bed at Shang-tsai-hsiu-tung. The plant fossils clearly contain lower Gondwana elements and also yield many representatives of the younger Cathaysian elements such as *Gigantopteris Yabei, Lobatannularia heianensis, Neuropteridium* and others. It also contains Middle Cathaysian elements. Therefore he concluded that it is to be regarded as part the oldest stage of the Younger Cathaysian flora, and correlated it to the fossil flora of the Tsaichia series in the vicinity of Pen-hsi-hu in South Manchuria. The fossil flora collected by KONNO at Kai-shan-tun are as follows.

Phyllotheca deliquescens (GOEPP.)
Lobatannularia heianensis (KODAIRA)
Sphenophyllum verticillatum (SCHLOTH.)
Sph. Thonii MAHR
Pecopteris cf. *Anderssonii* HALL
P. unita BRONGN.
P. cf. *Yabei* KAWASAKI
P. sp. nov. a
P. sp. nov. ? b
Odontopteris subintegra KONNO

Gigantopteris Yabei KAWASAKI
Emplectopteris triangularis HALLE
Callipteridium rarinervium KONNO
Neuropteridium longifolium KONNO
Brongniartites Imaizumii KONNO
Taeniopteris spp.
Rhipidopsis densinervis FEISTMNPEL
Rh. cf. *lobata* HALLE
Rh. cf. *gondwanensis* SEWARD

A conglomerate whose pebbles are cemented by ochre, pale green to pale blue, sandy clay is situated in the upper division of the middle part of the Touman formation. KONNO pointed out that this conglomerate is the basal conglomerate of the district, and he correlated it with the basal conglomerate of the Tsaicha formation. He also regarded the unconformities at the base of these two formations as equivalent to a hiatus at the basal part of the Middle Productus Limestone in India, and suggested that the Lower Gondwana flora first invaded the Far East at this time.

C. Permian System in the vicinity of Yu-chuan

Yu-chuan, east of Harbin, is a station on the Pin-sui line, and was formerly called Erh-tseng-tien-tzu. A Paleozoic formation which consists of sandstone, clay-slate and limestone crops out in this vicinity. AHNERT[1] collected many animal fossils from the limestone in this locality and FREDERIK identified the following 14 species and attributed them to the Middle Permian.

Brachiopods
Productus cf. *boliviensis* D'ORB.
P. weyprechti TOUL.
P. mammatiformis FREDR.
P. aculeatus MARTIN
P. waageni POTHP.
P. purdoni DAVIDS.
Paramarginifera peregrina FREDR.
Spirifer striatus mut. *neostriatus* FREDR.
Spiriferella rajah (SALT.)
S. lytha FREDR.
S. cf. *vercherei* WAAGEN
Bryozoa
Polypora sykeri WAAG.
Pelecypods
Aviculopecten cf. *subclathratus* KEYS.
Gastropods
Berellophon sp.

Recently, the writer[36] received several specimens from Shigemitsu OKADA, who had collected them from the greenish gray sandstone in the vicinity of Hsieh-

hsiao, about 8 km south of Yu-chuan. The writer identified the following fossils among them.

Brachiopods

Neospirifer moosakhailensis (DAVIDSON)
Waagenoconcha cf. *purdoni* (DAVID.)
Linoproductus cora (D'ORBIGNY)

Pelecypods

Pseudomonotis (Aviculomonotis) kazanensis (DE VERNEUIL)

In addition to these, there was an indistinct crinoid specimen. Though the state of preservation of these fossils is generally very poor, the fossils apparently correspond with those of the Jisu Honguer limestone in the Far East. Therefore they are regarded as evidence of the Lower Permian. The Permian System in the vicinity of Yu-chuan appears as sediments of the last marine transgression in the Mongolian Geocyncline as indicated by the fossils present.

D. Solun formation

Torao HATTYO formerly collected several fossil specimens at So-lun (Hsi-cha-ka-erh-chi), on the eastern side of the middle part of the Ta-hsing-an-ling Mountain range, about 100 km northwest of Hsing-an (Wang-yeh-miao). Teiichi KOBAYASHI[11] identified these fossils and reported such pelecypods as *Aviculopecten khinganensis* KOBAYASHI, *A. (Deltopecten)* sp., *Crenipecten soronensis* KOB. and a gastropod *Pleurotomaria yabeshigerui* KOB.

He reported that the age of these fossils points to some age from the post-Devonian to the Permian, and that since all these fossils are new, the precise age cannot be determined. The fossils were yielded from tuffaceous sandy shale in the above-mentioned alternation, which was named the So-lun formation by KOBAYASHI.

Later Lihsu CHANG[2] collected fossil specimens of pelecypods from the relatively massive, yellowish, dark gray shale and the overlying yellowish gray fine-grained micaceous sandstone at the side of a road which passes from the bank of the Hahai River, north of So-lun to the hot spring. KOBAYASHI and HISAKOSHI identified *Carbonicola? khinganensis* KOBAYASHI and HISAKOSHI, *C? soronensis* K. and H., *Palaeomutela hahaiensis* K. and H., *P. chaoi* K. and H., *P. subrectangularis* K. and H., and an allied species of *Palaeonodenta longissima* HATSCHEF, collected by FEDOTON from the Upper Permian Kolchugino series in the Kuznetsk Basin. They concluded that the Hahai fauna may perhaps indicate the later half of the Permian and may be situated at a horizon above that of the above-mentioned *Aviculopecten* fauna. According to CHANG, the geology of this fossil locality consists essentially of an alternation of brownish yellow sandstone and black gray or dark blue clay-slate and the clayslate sometimes grades to phyllitic rock. The strike shifts from N 80° E to N 70° W and the dip is also very variable, but it is generally steep except for several cases. Thus, synclines and anticlines are developed on a small scale.

As will be seen from the above description, the exact relationship between the

Solun formation and the Hahai fauna is not yet distinct; however it is not unreasonable to infer that both are related to the Mongolian Geosyncline. One rather remarkable character is that no fusulinid specimens have been obtained from the Jisu Honguer formation and the Dabus Nor formation, and the same is true in the Yu-chuan and the Solun formations as well as the Hahai fauna. In a report on the Jisu Honguer formation, GRABAU[5] pointed out that this situation arises from the fact that no connection existed between the Mongolian Geosyncline and the waters of the Pacific Ocean at that time. Even the Permian System of the North Manchurian type, the Touman formation and the system in the vicinities of Vladivostok and Khabarovsk, which may be prolongations of the Touman formation, yield many fossil specimens of fusulinids. They are, therefore, to be regarded as having been deposited in the Pacific area, which differed and was separate from the Mongolian Geosyncline.

IV. Conclusions

1. The Manchurian Carboniferous and Permian Systems are composed of two different types of sedimentation. One is represented by the Taitzuho System of the South Manchurian type, i.e., the coal-measures, and the other is the marine formation of the North Manchurian type.

2. The Taitzuho System rests on the Ordovician Ssuyen formation and is overlain by the Lower Cretaceous Miyanohara complex. The stratigraphic relations between these three systems is always parallel unconformity. However, as in the case of the Niu-hsin-tai coal field, some formation of unknown age is sometimes interbedded in parallel unconformity between the Ssuyen formation and the lower formation (Penhsi series) of the Taitzuho System.

3. The Taitzuho System is subdivided into the Penhsi, Huangchi (Yatang), Liutang and Tzaichia series in ascending order. Parallel unconformities are found between the former two and the latter two series. However, the relation between the Huangchi and Liutang series is conformable.

4. The Penhsi series is equivalent to the so-called Penchi Series in North China and the Koten series in Korea, and the age can be regarded as Middle Carboniferous, namely Moscovian. The Huangchi series (Yatang series) corresponds to the lower part of the Yuehmnkou series (Taiyuan series) in Shan-hsi and the lower part of the Jido Series in Korea and is apparently lowermost Permian or Sakmarian in age. The Liutang series coincides with the upper part of the Yuehmengkou series (Shanhsi Series) in Shan-hsi and the upper part of the Jido series in Korea, and its geological age is to be recognized as Lower Permian, the lower part of the Lower Rotliegendes. Lastly, the Tsaichia series can be correlated with the Shihhotzu series in Shan-hsi and the Kōbōsan series in Korea and is to be regarded as approximately Upper Permian in age.

5. The coal-seams in the Penhsi, Huangchi (Yatang) and Liutang series are of brackish water deposition while the formations between coal seams are of

shallow sea water deposition, no matter whether limestone exists or not. However, upwards, the degree of transgression may become gradually less.

6. The Carboniferous and Permian Systems along the Hun Chiang River are the eastern prolongation of the Taitzuho system in the Taitzuho district. The Penhsi series of this district is well developed, as in the Taitzuho district. Though the Permian Takang series is apparently equivalent to the Liutang series in the Taitzuho district, it may also include the Huangchi series. The Techang series coincides with the Tsaichia series.

7. The Hunglohsien and Hamashan series rest on the Middle Ordovician limestone in the Chin-chou and Jeho districts, and these series are overlain by Mesozoic formations; the stratigraphic relations between these systems are always parallel unconformities. Though it is clear that the Hunglohsien series corresponds with the Huangchi and Liutang series in the Taitzuho district, it is as yet unknown whether the part that can be correlated with the Penhsi series develops or not. The Hamashan series is the equivalent of the Tsaichia series.

8. Some part of the boundary between the South Manchurian and North Manchurian types may have existed merely in a paleogeographical sense. However, the formations of the North Manchurian type which are not separated from the Penhsi series by fossils and sedimentary facies crop out in the vicinity of Yen-tung Shan, Pan-shih Hsien, Chi-lin Province and in a place about 200 km north of Chang-chia-kou, Inner Mongolia. Moreover, compressed and brecciated gneiss is extensively distributed near the boundary line between these two types in the vicinities of Ta-tien-tzu, An-t'u Hsien, Chi-lin Province and at the boundary line between An-tung and Chi-lin Province. Therefore the geological tectonic meaning must also considered.

9. The Carboniferous and Permian Systems of the North Manchurian type can be divided into three formation groups, namely the Chilin formation, the Touman formation and formation type near Yu-chuan. However, it is not possible at present to infer that the depositional basins of these three groups were connected with each other chronologically and geographically.

10. The Chilin formation consists essentially of the Middle Carboniferous including a part of the Devonian System. However, there is some possibility that older formations will be found after further investigation. This formation is sporadically distributed from the north of the type locality to Siberia in the far north.

11. The Touman formation belongs to the Permian, and extends to the vicinities of the Ussuri River and Vladivostok from the district of the Tou-man River. It is suspected that the Touman formation may overlap the Chilin formation at its western end.

12. The Permian System in the vicinity of Yu-chuan is the last deposition of transgression connected with the Mongolian Geosyncline. There is no indication that the present basin was connected with the depositional basin of the Touman formation. If the eastern margin of this transgression is at Yu-chuan, however,

Table 12. Correlation of the Carboniferous and Permian Systems of Manchuria.

Area / Period		North China		Korea			South Manchuria			North Manchuria		
							Taitzuho district	Hunchiang district	Chinchou-Jeho district	Chilin district	Touman R. district	Yuchuan district
Permian	Upper	Shihhotzu series		Heian system	Kobosan series	Taitzuho system	Tsaichia series	Techang series	Hamashan series	?	Touman formation	?
	Lower	Yuehmenkou series	Upper (Shanshi series)		Jido series Upper		Liutang series	Takang series	Hunglohsien series		?	
	Lowermost		Lower (Taiyuan series)		Lower		Huangchi series (Yatang series)	?		(Permian)		Yuchan Permian
Carboniferous	Middle	Penchi series			Koten series		Penhsi series	Penhsi series	?	Chilin formation		
	Lower	Laiwu formation (undated)					Niuhsintai Conglomerate (undated)					
Devonian												
Silurian										?		
Pre-Silurian		Middle Ordovician Limestone								Older Rocks		

there is a great possibility that the same formation will be found in the western part of North Manchuria, west of Yu-chuan.

13. To sum up and clarify the discussion in the preceeding pages, Table 12 presents a generalized correlation of the Carboniferous and Permian Systems in Manchuria.

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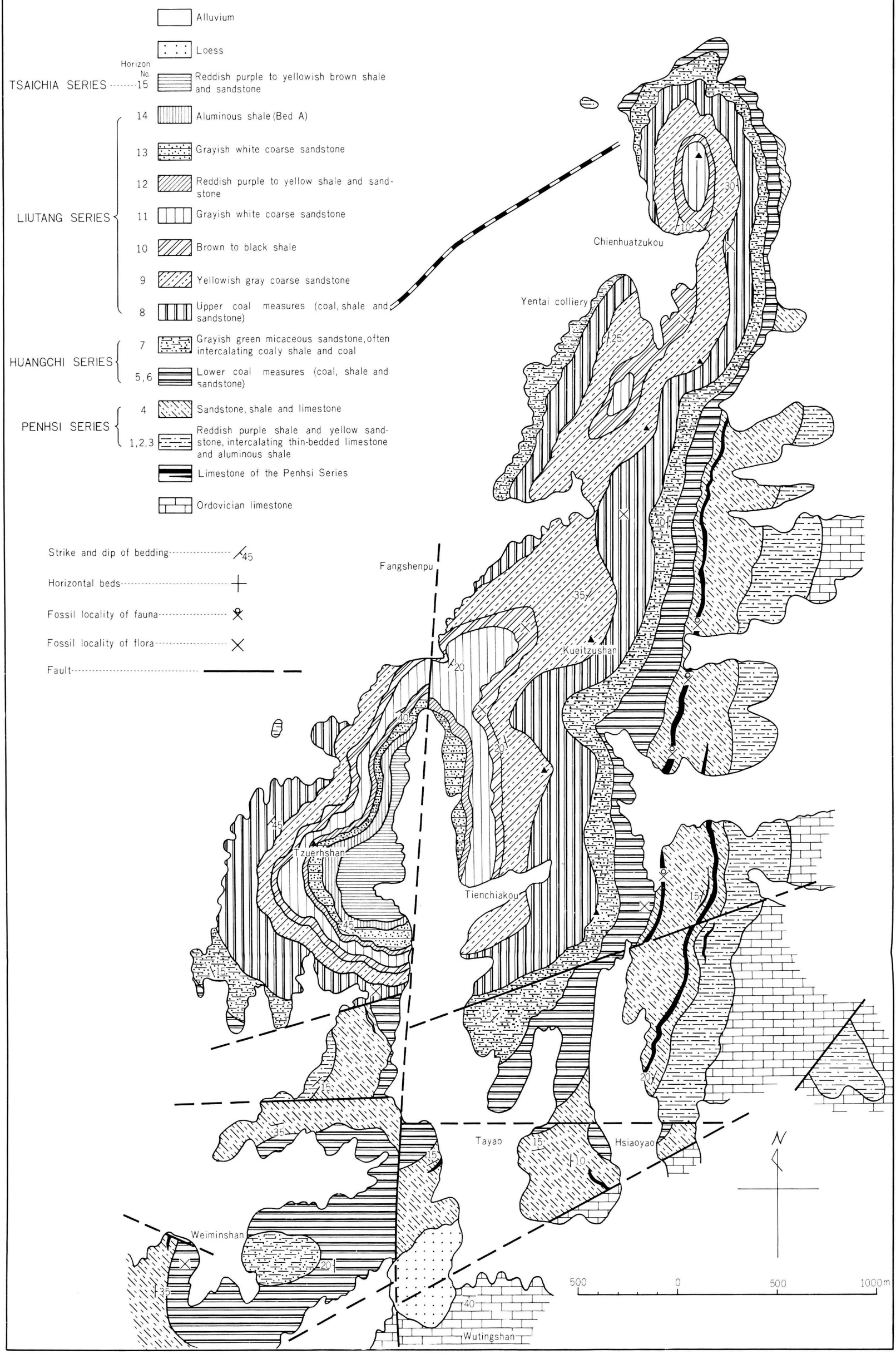

Fig.5. Geologic Map of the Yen-tai Coal Field

N

500 0 500 1000m

Huangchikou

Liutang

Ssuyenkou

PENHSIHU

Tsaichiatun

Miyanohara Station

Taitzuho

I II III

Alluvium

MIYANOHARA SYSTEM
- Grayish white coarse sandstone and variegated shale
- Conglomerate with large pebbles of quartzite
- Reddish purple, cross-bedded coarse sandstone
- Conglomerate, cementing with reddish purple sandstone

TSAICHIA SERIES (Horizon No.)
- 18 Variegated shale, sandy shale and sandstone
- 17 Reddish purple shale and grayish white sandstone
- 16 Grayish white coarse sandstone, with some layers of abundant small quartz pebbles
- 15 Reddish purple to yellowish brown shale and sandstone, intercalating a layer of aluminous shale (Bed Ao) in the upper part

LIUTANG SERIES
- 14 Aluminous shale (Bed A)
- 13 Grayish white coarse sandstone
- 12 Reddish purple to yellow shale and sandstone
- 11 Grayish white coarse sandstone
- 10 Brown to black shale
- 9 Yellowish gray coarse sandstone
- 8 Upper coal measures (coal, shale and sandstone)

HUANGCHI SERIES
- 7 Grayish green micaceous sandstone, often intercalating coaly shale and coal
- 6 Lower coal measures (coal, shale and sandstone)
- 5 Grayish white coarse sandstone and grayish black sandy shale

PENHSI SERIES (Horizon No.)
- 4 Sandstone, shale and limestone
- 3 Reddish purple to black shale and yellow sandstone, occasionally intercalating a layer of lenticular limestone
- 2 Yellow coarse sandstone and sandy shale
- 1 Reddish purple sandy shale, intercalating layers of aluminous shale (Beds G and F)

Limestone of the Penhsi Series

Pre-Carboniferous rocks

Andesite

Fossil locality of fauna

Fossil locality of flora

Fault

Strike and dip of bedding

Strike of vertical strata

Horizontal beds

Location of drill hole

Fig.6. Geologic Map of the Pen-hsi-hu Coal Field

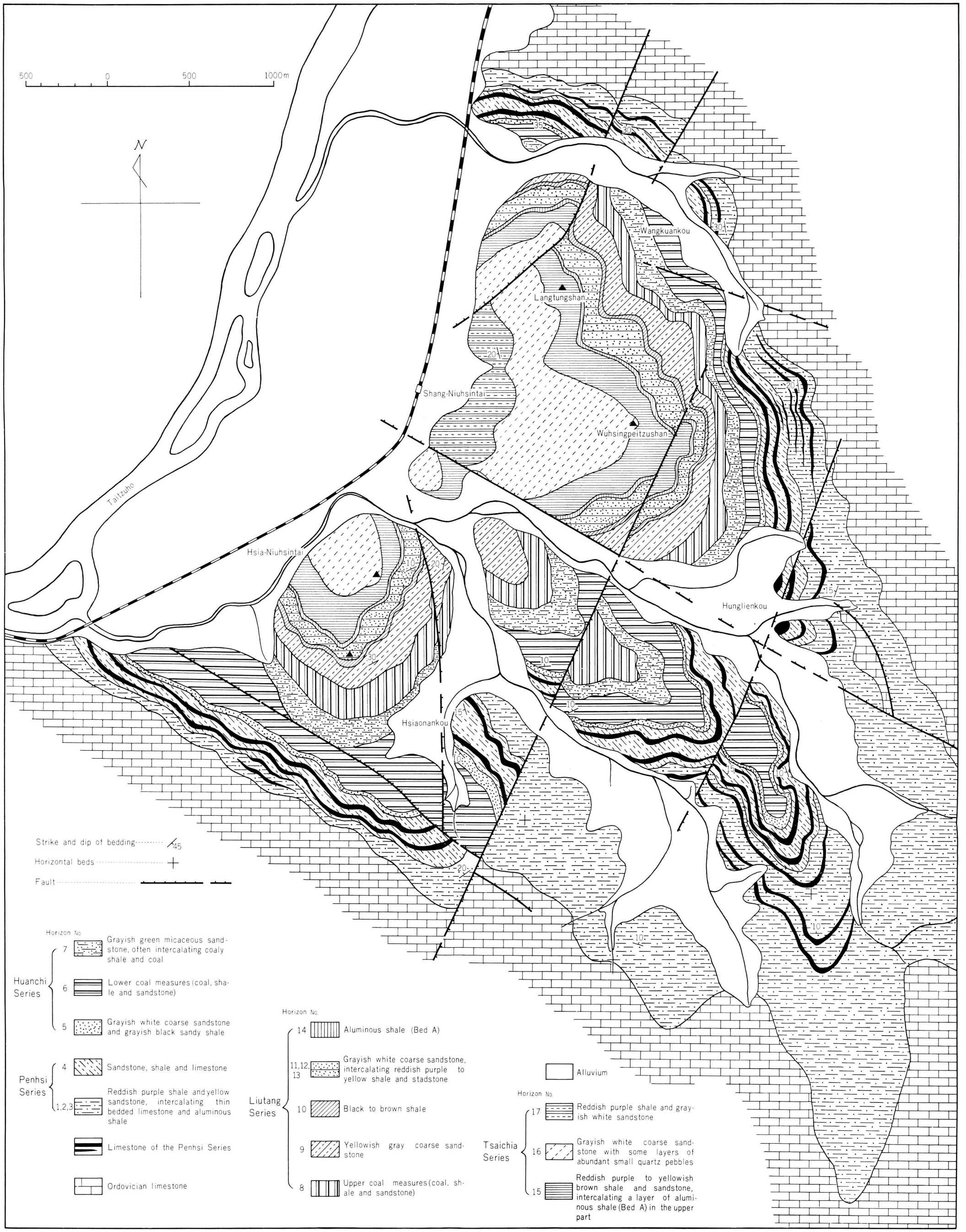

Fig.7. Geologic Map of the Niu-hsin-tai Coal Field

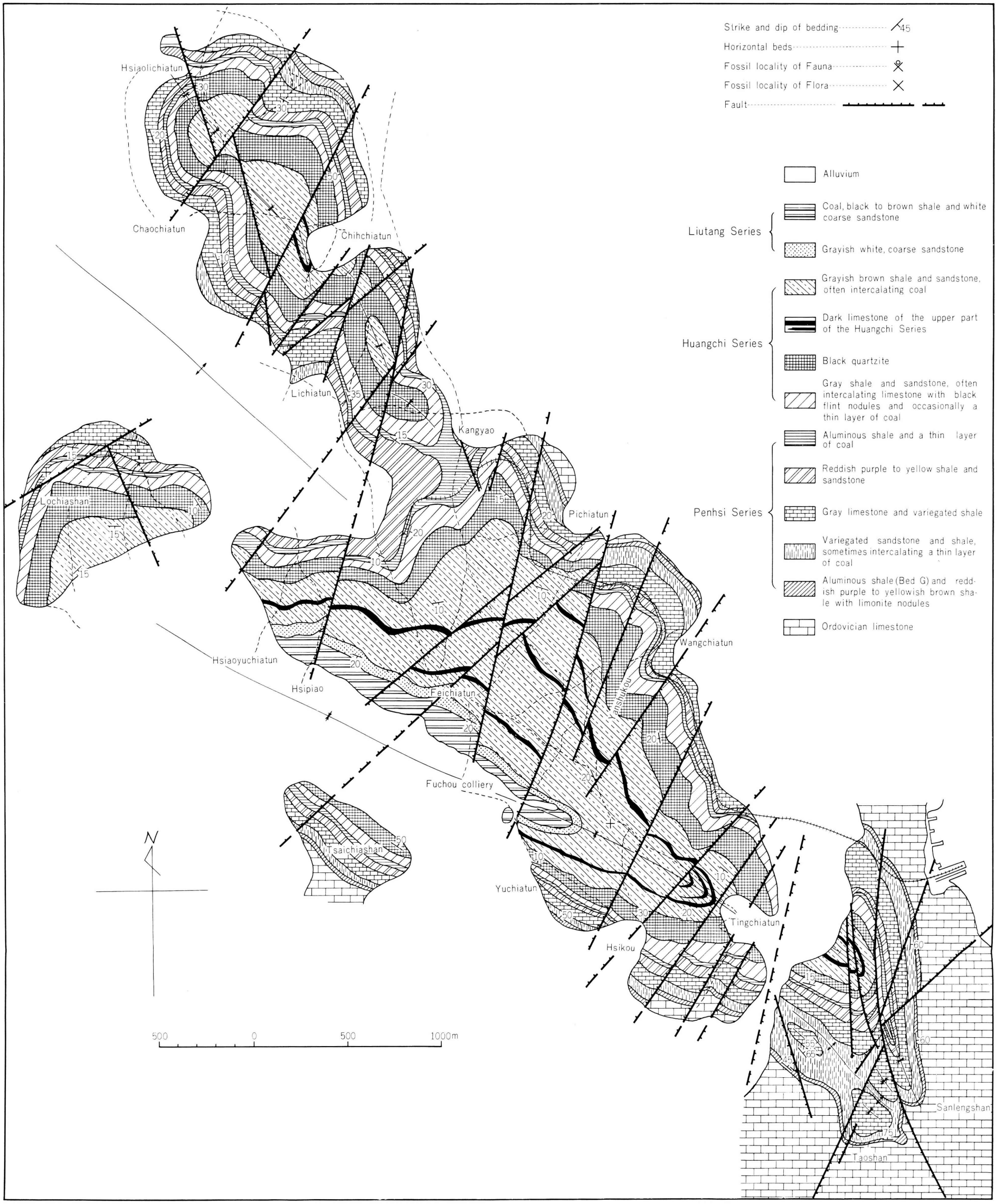

Fig.8. Geologic Map of the Fu-chou (Wu-hu-tsui) Coal Field

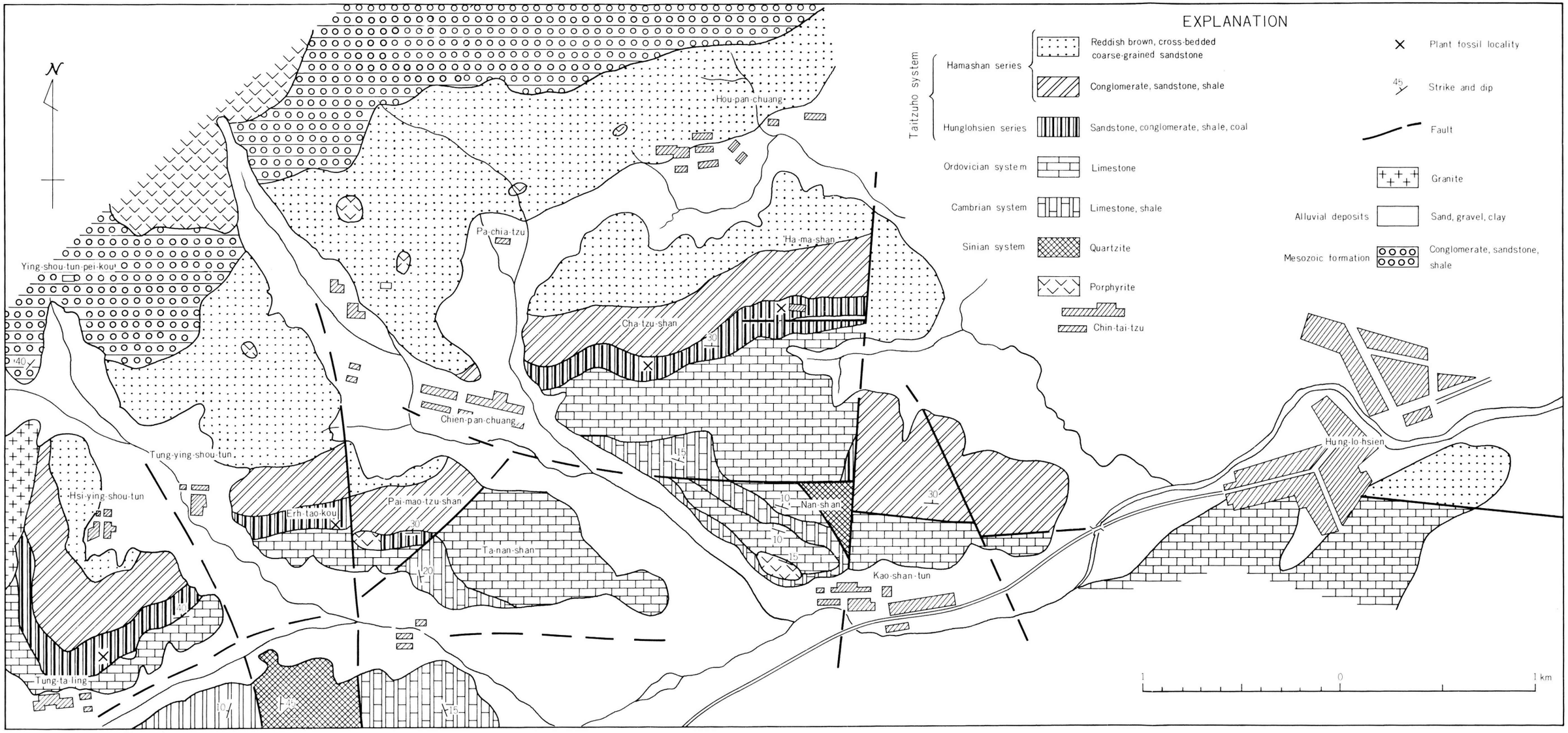

Fig.9. Geologic Map of the Hung-lo-hsien Coal Field

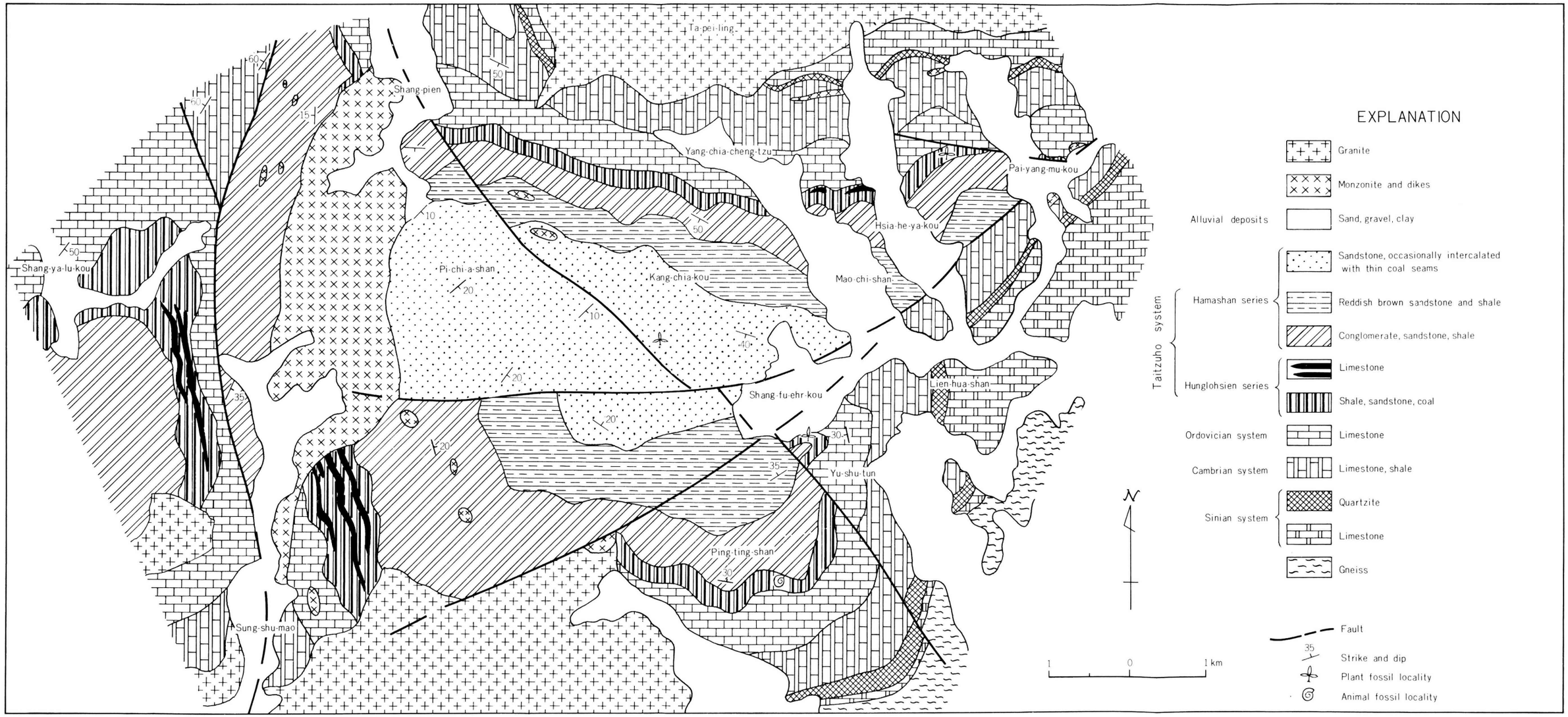

Fig.10. Geologic Map of the Yang-chia-cheng-tzu Coal Field