Studies on the Geologic Structure of the Phyongyang Coal Field, Korea

Nakamura, Shintaro; Matsushita, Susumu; Kobatake, Nobuo; Ikebe, Nobuo

Memoirs of the College of Science, University of Kyoto, Series B,
Vol. XXIII, Special Number, 1957

Studies

on

the Geologic Structure

of

the Phyongyang Coal Field, Korea

By

Shintaro NAKAMURA†,

Susumu MATSUSHITA, Nobuo KOBATAKE and Nobuo IKEBE

Kyoto University Osaka University Osaka City University

1957

Preface

During his tenure of office as a geologist of the Governor-General of Korea for eight years and a half from 1911 to 1919, our respected teacher the late Prof. Shintarô Nakamura carried out his surveying journey throughout the Korean peninsula, making a great contribution to the exploitation of mineral resources of various kinds and the progress of geology in Korea. His scope of researches covered the various fields of stratigraphy, tectonics, fossils, mineral resources, minerals, physical geography and human geography. His research works did not cease when he retired from this service in Korea and was transferred to the Kyôto Imperial University.

Of many research problems in which he felt interest, the very one, which he took as his best subject of research in his whole life and made his greatest efforts to solve, was nothing but the geologic structure of the Phyongyang (Heijô) Coal Field.

We are told that when Prof. Nakamura surveyed the coal field in company with Prof. Hisakatsu Yabe in 1914, having recognized the complexity of geologic structure of the coal field, he began to hope his future thorough study on that problem.

In November 1916 Dr. I. Kikkawa, then a mining engineer of the Jidô coal mine, discovered Cambrian trilobites at Sadong (Jidô) near Phyongyang in a sandstone-shale bed (Shôra bed) apparently conformably overlying the lower Permian Jidô Series. This was an important discovery, since it served as a guide to solve the geologic structure. Having been much excited by this discovery, Prof. Nakamura hurried there in June next year to carry out a precise observation and confirmed that the Shôra bed was thrust up on the Jidô Series. He gave the name of the Jidô thrust to the thrust and made public his treatise, entitled "the Jidô thrust" in the Journal of the Geological Society of Tokyo, in its February 1918 issue. This was the commencement of his research on the geologic structure of the Phyongyang Coal Field.

When he was transferred to Kyôto at the end of 1919, he began to prepare for the regular survey all over the coal field, and at last in the autumn 1924 he carried out his regular field work on the geologic structure of the coal field, in the area to the south of the coal field. He wrote, "I carried out the research on these older formations in the area to the south of the coal field, since I believed that the best method to make clear the geologic structure of the Phyongyang Coal Field is to study at first the stratigraphy and structure of the Shôgen and Chôsen Systems underlying the coal-bearing Heian System" (1932 a).

Such being the case, he engaged in the field survey in the Tyunghoa (Chûwa)—Pisyokkol (Hisekidô) districts several times during the period from 1924 to 1932. Matsushita surveyed the older formations in the district to the northeast of Phyongyang in 1931 and 1932, and Kobatake commenced his study on the Heian System of the coal field under consideration in 1931.

Untill that time the field surveys were made only in some small parts of the whole field to be worked out. But in 1934 Prof. Nakamura was given the aid from the Japan Society for the Promotion of Science for his study on the geologic structure of the coal field in question. During the period from 1934 to 1938, directing his several pupils (Susumu Matsushita, Nobuo Kobatake, Shunrō Maejima, Hisamichi Matsushita, Nobuo Ikebe, Kiyoshi Takimoto and Tsuneshige Suzuka) he carried out field works in the whole area of the coal field under consideration and its surrounding districts covering 2,702 square kilometers. Let us quote a paragraph of Prof. Nakamura's preface to "Studies on the Geologic Structure of the Phyongyang (Heijô) Coal Field, I" by the late Mr. S. Maejima. "Phyongyang with its vicinity is a memorial place where the mutual relations among the geologic formations of various ages of Korea have been made clear to the present state. I believe that to solve the complicated geologic structure of the Phyongyang district will contribute to the solution of the stratigraphy and geologic structure of East Asia. And the study of the geologic structure will give no small profit to the coal mining industry of Phyongyang producing nearly 1,000,000 tons annually. In order to execute the study on the geologic structure of the coal field, it is needed to study the basement of the coal field as well, accordingly I have taken as the area to be studied the area occupying 2,702 square kilometers ranging from 125°25′ E to 126°15′ E and from 38°50′ N to 39°10′ N."

The allotted areas to study of the collaborators cited above and the years of their field study are as follows.

S. Matsushita: The district northeast of Phyongyang, 1931-1936, and the Kangtong (Kôtô) district, 1935-1937.

N. Kobatake: The elongated area including the Kobangsan (Kôbôsan) hill, Wontan (Gentan) hill and the Taisei colliery, 1930-1937.

S. Maejima: Phyongyang-Sadong (Jidô) district and the district to the west of Phyongyang, 1934-1938.

H. Mastushita: Daimonzan colliery district, 1934.

N. Ikebe: Western margin of the coal field including the Kôsai coal mine and the Taihô coal mine, 1934 and 1938; Samtung (Santo)—Syangwon (Shôgen) district, 1935-1938.

K. Takimoto: Kanpoku coal mine and its north, 1934.

T. Suzuka: The district to the southeast of Kiyang (Kiyô), 1934.

Though the results of the research were partly and separately reported by Prof. Nakamura and his collaborators, the formal and complete report of the research have not yet been published. In order to celebrate Prof. Nakamura's sixtieth birthday, 21 April 1941, by publishing the results of his research on the geologic structure of the Phyongyang Coal Field prepared by himself, subscriptions were made by his friends and pupils before that date. But having been compressed with business, his writing did not progress, and it was not possible to publish by his sixtieth birthday. Therefore he decided to prepare the treatise and map after his retirement from university. But unfortunately he fell ill in the spring of 1941 and died on 8 Dec. 1941, leaving his work to us.

In such circumstances we succeeded the work to arrange and synthetize all the results of the studies. During the war-time, the geologic map and sections were prepared and put to press, but their copperplates were lost unfortunately by the air-raid in the spring of 1945 just before the final print. The treatise was partly written in the war-time, and its remaining part has been prepared after the end of the war.

On account of the post-war economic conditions of our country, it has been fairly difficult to publish geologic maps and treatise. At last we were compelled last year to organize a society for publishing Prof. Nakamura's posthumous work by raising subscriptions for that purpose. On the other hand, fortunately our society has been subsidized by the Education Ministry.

Though we have endeavoured to follow Prof. Nakamura's will by reading his field maps, arranged maps, field notebooks, treatises and recalling his talks in his life-time, the prepared treatise and map may be, to our regret, incomplete and distant from his intention, and our interpretation of the geologic structure may be contrary to his view.

We should like to express here our heartiest thanks to the officials of each coal mine of Phyongyang Coal Field, who aided us in many ways. As mentioned before, our field works during the period from 1934 to 1938 were carried out by the aid of the Japan Society for the Promotion of Science. Many thanks are due to the fomer authorities and members of the Society. The publication has been realized by the subscriptions in 1940, 1955 and 1956 together with the subsidy from the Education Ministry. We should like to acknowledge the subscribers and the Education Ministry officials in charge of the subsidy. We are much indebted also to Prof. Jirô Makiyama for his kind help to our task in many ways.

Susumu Matsushita, Nobuo Kobatake and Nobuo Ikebe

June, 1956

CONTENTS

Geologic Map of the Phyongyang Coal
Fied, Korea (1:100,000)

LIST OF TABLE

LIST OF PLATES

LIST OF TEXT-FIGURES

Studies on the Geologic Structure
of
the Phyongyang Coal Field, Korea

By

Shintarô NAKAMURA †,

Susumu MATSUSHITA, Nobuo KOBATAKE and Nobuo IKEBE
Kyôto University Ôsaka University Ôsaka City University

Introduction

The Phyongyang Coal Field is situated in South Pyongam-do, extending east and west through the city of Phyongyang (Heijô), with a length of 56 km, a maximum width of 21 km and an area of 400 km². The coal field under consideration is the earliest exploited and most developed coal field in Korea.

Many researches on the geology of this coal field have been made up to the present. A brief historical sketch of the geological research of the coal field is stated below. It may be convenient for this purpose to divide the whole age of research into the following five stages.

The first stage (the dawn of the research history) : 1884-1903.
(for twenty years until the outbreak of the Russo-Japanese War).
The second stage (the reconnaissance period) : 1904-1909 (from the Russo-Japanese War to the annexation of Korea).
The third stage (the precise survey period I) : 1910-1920.
The fourth stage (the precise survey period II) : 1921-1933.
The fifth stage (the precise survey period III) : 1934- .

The first stage. A German geologist C. Gottsche was the first to describe the geology of the Phyongyang Coal Field (Gottsche, 1886, 1889). He surveyed for the first time the geology of the Korean peninsula in 1884. He gave a brief account on the foundation of Phyongyang i.e. the Jurassic Daidô System which was assumed by him as the Tertiary and the coal measures in the Sadong (Jidô) district and the Samtung (Santo) district. J. Felix studied the silicified wood collected by Gottsche from the Daido System of Phyongyang and assumed its age as not older than the Triassic (1887). The rock specimens Gottsche collected were later studied by K. Schulz (1910). After Gottsche's survey, no one investigated the geology of the Phyongyang Coal Field for a long time, until 1895 when K. Nishiwada surveyed there (Nishiwada, 1898).

The second stage. During and immediately after the Russo-Japanese War some geological survey was carried out in the coal field by N. Fukuchi, I. Sugimoto, S. Matsuda, S. Sasao, T. Iki and S. Suzuki (Fukuchi and Sugimoto, 1905; Iki, 1906; Iki and Suzuki, 1906; Inouye, 1907, 1913, 1914; Matsuda and Sasao, 1906). Though it was a reconnaissance, it added much in several points to the geological knowledge of the coal field. The fusulinid fossils discovered from the limestones of the coal measures showed that the coal measures are upper Palaeozoic and must be separated from the Mesozoic on which the town of Phyongyang stands. Beside this survey, at the invitation of the Korean government, T. Kochibe engaged in the geological survey of the Phyongyang and other coal fields and graphite deposits of Korea during the years from 1905 to 1909 (Kochibe, 1908). M. Yokoyama described some fossil plants from Phyongyang (Yokoyama, 1906). The coal of the Phyongyang Coal Field, though on a small scale, had for a long time from ancient times been mined and used, but its regular exploitation was started around in 1907 on the ground of these investigations.

The third stage. Korea was annexed to Japan in 1910, and next year a mineral resources survey throughout the peninsula commenced. As a part of the survey the Phyongyang Coal Field was investigated by E. Tamura (Tamura, 1917).

With the progress of the prospecting and mining at the Jidô (Sadong) and the Kôbôsan (Kobangsan) Collieries, fossils were discovered one after another from many formations. In 1912 I. Kikkawa succeeded in finding some plant fossils from the coal measures (Kikkawa, 1925). In 1912 and 1913 S. Tokunaga and in 1914 H. Yabe made field works in the coal field under consideration. They investigated independently of each other the stratigraphy and fossils of the coal measures there, and concluded that the age of the coal measures of this coal field is Permo-Carboniferous (Tokunaga, 1913a, 1913b, 1914; Yabe, 1914, 1919). Further in 1916 Kikkawa made great contributions to the geology and the mining industry of Korea in finding Cambrian trilobites from a bed apparently overlying the coal measures (Kikkawa, 1925).

As the first step of the research on the geological structure of the Phyongyang Coal Field, the Jidô thrust was investigated by Nakamura who was much excited by Kikkawa's important discovery mentioned above

(Nakamura, 1918).

The fourth stage. In this stage, were made field works with a higher degree of precision than ever and the more advanced researches than ever in each field of stratigraphy, geologic structure and fossils.

Many detailed studies were made on the plant fossils by H. Yabe (1922, 1929, 1930), S. Kawasaki (1925, 1927, 1931, 1932, 1934), E. Kon'no (1928, 1929, 1932, 1933) and S. Oishi (1929, 1930, 1931a, 1931b), and on the fossil animals chiefly cephalopods and gastropods, and stratigraphy of the Ordovician underlying the coal measures in the Mantalsan (Bantatsusan) district by T. Kobayashi (1929, 1930, 1931).

Now the researches on the stratigraphy and geological structure of the coal field under consideration became active and successive. After his geological research in the Taisei coal mine district in the eastern part of the coal field, Kon'no turned to the studies in the western part of the coal field and discovered a marked thrust which he called the Taihô thrust (Kon'no, 1928). As the basis of his structure studies on the Phyongyang coal field, S. Nakamura executed the studies on the stratigraphy and complicated structure of the Lower Palaeozoic and Proterozoic in the Tyunghoa-Pisyokkol district situated to the south of the coal field proper (Nakamura, 1926, 1932a, 1932b). K. Saitô studied the Cambrian stratigraphy, fossils and geological structure in the Tyunghoa district (1933a, 1933b, 1934, 1936). Leading the students of the Tôhoku Imperial University, S. Shimizu executed a detailed survey of the stratigraphy and structure of the coal measures in the eastern half of the coal field. K. Ozaki discovered brachiopod fossils from a shale of the Kôten Series (Ozaki, 1934).

In the years of 1928 and 1929, as a part of the surveying work of the Fuel and Dressing Research Institute of the Governor-General of Korea, R. Kodaira engaged in the precise surveying of the whole area of the Phyongyang Coal Field.

The fifth stage. In this stage were made Nakamura's regular studies on the geological structure of the Phyongyang Coal Field. As mentioned already in the preface, he executed the precise and detailed field works, with several collaborators, throughout the whole scheduled area for four years from 1934 to 1938 (Nakamura, 1932b, 1935, 1936a, 1936b, 1938; Matsushita, 1933, 1937, 1938a, 1938b, Matsushita, Kobatake and Ikebe, 1952; Kobatake, 1935, 1937, 1941, 1953; Ikebe, 1935, 1937, 1939; Maejima and Takimoto, 1937). Meanwhile S. Shimizu and T. Oose, then geologists of the Chôsen Anthracite Co. Ltd. investigated the coal measures (Shimizu and Oose, 1939). N. Hatae investigated the stratigraphy and the fusulinid fossils of the Heian System (Hatae, 1935, 1938, 1941). M. Shimakura studied on the fossil woods from various localities including Phyongyang (Shimakura, 1934, 1936, 1937).

Stratigraphy

General

The major geological formations which constitute this region are tabulated as follows:

	Taihô System	2,000 m	Conglomerate, sandstone, shale, tuff, tuff breccia, porphyrite, quartz-porphyrite.	Late Lower Cretaceous~ Early Upper Cretaceous
		~~ Unconformity ~~~~~		
	Daidô System	1,300	Sandstone, shale.	Lower and Middle Jurassic
		~~ Unconformity ~~~~~		
Heian System	Taishiin Series	650	Shale, sandstone, conglomerate.	Uppermost Upper Permian~ Lower Triassic
		~~ Disconformity ~~~~~		
	Kôbôsan Series	350–500	Shale, sandstone.	Upper Permian
	Upper Jidô Series	100–200	Shale, sandstone & anthracite	Lower to Middle Permian
	Lower Jidô Series	50–150	Shale, sandstone, limestone & anthracite	Lowest Permian (Sakmarian)
		~~ Disconformity ~~~~~		
	Kôten Series	250–300	Shale, limestone.	Middle Carboniferous
		~~ Unconformity ~~~~~		
Chôsen System	Great Limestone Series	1,000	Limestone, dolomite.	Middle Cambrian~ Middle Ordovician
	Chûwa (Yôtoku) Series	420	Shale, slate, sandy shale, limestone.	Lower-Middle Cambrian
		~~ Unconformity ~~~~~		
Shôgen System	Kuken Series	310	Slate, siliceous slate, quartzite.	
		~~ Unconformity ~~~~~		Upper Proterozoic
	Shidôgû Series	400–700	Limestone, dolomite.	
	Chokken Series	510–700	Quartzite, phyllite.	
		~~ Unconformity ~~~~~		
	Kokulian Granite		Gneiss, granite.	
		——— Intrusive contact ———		
	Keirin System		Mica-schist, phyllite.	

Generally speaking, each formation is elongated in the east-west direction. The Heian System forms the median axis, on both sides of which are arranged older formations. The most important formation is the coal-bearing Jidô Series of the Heian System. The Daidô and the Taihô Systems are restricted in the west part of the coal field.

The Keirin System

This name was given by Nakamura in 1939 to the Pre-Kokulian system composed of metamorphic rocks of sedimentary origin in Korea; Keirin is another name of Shiragi, an acient Korean state situated in the southern part of the Peninsula. This system comprises the Matenrei System in North and South Hamgyong-do (Kankyô-dô) and the Rensen System in Keiki-dô etc. As in the other regions, the Keirin System in this region is injected by the Kokulian Granite in various grades: thus in some cases the latter occurs in the former for more than several kilometers, while in other cases the Kokulian alternates with the Keirin in a width of several to several hundreds meters, and further in the other cases the granite is minutely injected forming meta-gneiss and injection-gneiss (Pl. XIX, fig. 1). The area where the Keirin is not accompanied by granite is also large.

The Keirin System occurs most broadly in the northwestern corner of the mapped area. It is distributed as well in the area to the north of Phyongyang and in the area to the west of Mt. Muhak at the western margin of the coal field.

The Keirin System is composed of mica-schist, mica-gneiss, phyllite, quartzite etc. The grade of metamorphism of rocks is not uniform. Generally speaking, the grade is higher in the western part of the region than in the eastern part.

The rocks belonging to the Keirin System have been all subjected to the dynamo-thermal metamorphism. A marked example of the rock subjected to the metamorphism is represented by the garnet-staurolite-cyanite-biotite-gneiss which is exposed at the northeast of Shasenshi.

The metamorphosed sedimentaries of the Keirin dip southeast at 60° in the Kumtyoe-myon (Kinsai-men) district, SSE or SSW in the Taekyongli (Zaikyô-ri) district, SSW at 35° in the Haksanli (Kakusanri) district, SE at 30-60° in the neighbourhood of Nongsong (Ryûjô), and are severely folded at the Taepo (Taihô) hill.

Kokulian Granite

This was named by Nakamura in 1927, its another name being the Grey Gneiss. It composes the mountain-mass of Muhaksan at the western extremity of the coal field and occurs widely in the southeast corner of the mapped area. The granite is seen injected besides into the Keirin System. The rock composing the mountain of Muhaksan is a biotite-gneiss, sometimes with banded structure, and is called the Muhaksan Granite-gneiss. The schistosity plane strikes N 60-75°W, dipping NNE at 25-35°. The Kokulian Granite occupying the southeastern corner of the mapped area is also biotite-gneiss or schistose biotite-granite, and it strikes N 70°W in its eastern part, N 40°E in the western part, dipping north. The gneiss injected into the Keirin mica-schist in the district between the Yongsong and Malan stations of the Phyongyang-Wonsan railway line is often banded and its feldspar is exclusively albite.

Shôgen (Syôgen) System

Overlying unconformably the Keirin System or the Kokulian Granite, there exists the Upper Proterozoic Shôgen System composed of rocks which have scarcely been subjected to metamorphism. The system is the Korean equivalent of the Sinian System which is distributed in South Manchuria and North China. In this mapped area the system is distributed in the eastern part and was named by Nakamura in 1926 after the name of a small town Syangwon (Shôgen) in the southeast part of the mapped area, in the Tyunghoa (Chûwa) county of South Pyongam-do.

As mentioned above, the Shôgen System is divided in descending order into the Kuken Series, the Shidôgû Series and the Chokken Series. Both upper and lower series consist of clastic rocks, while the middle series is composed of carbonate rocks.

The stratigraphy of this system in the type district of Shôgen was first studied by Nakamura in 1925 and afterwards by Ikebe in 1937. According to Ikebe, the Shôgen System is as a whole 1,700 meters thick and its stratigraphy is as follows:

Kuken Series	10-50 m.
Shidôgû (Sidôgû) Series	1,000 m.
Chokken (Tyokken) Series	700 m.

The Chokken Series is composed almost wholly of green phyllite with the exception of quartzite, 5-20 m thick at the base of the series. The relation between the series and the underlying Kokulian Granite is unconformable. The stratification plane of the series is nearly parallel to the schistosity plane of the underlying gneiss. In the green phyllite are often intercalated the lenticular grey white limestone with a thickness of more than 10 meters in some cases. At the middle horizon of the green phyllite formation is intercalated a quartzite bed showing complex folding. At the top of the Chokken Series, there lies a black phyllite bed about 5 meters thick.

The Shidôgû Series is stratigraphically divided as follows. The lower part is a grey, platy, crystalline limestone; the middle part is a white, massive or platy, compact dolomite; the upper part a grey, thin platy limestone with a horizon of *Collenia;* the uppermost part is frequently occupied by a massive dolomite.

The Kuken Series consists of black (when weathered, light pink, green, grey white) slate, and sometimes a part of it passes into grey white, green, light pink siliceous slate or slaty quartzite, variable in thickness. In the Kuken often occur sills of diabase.

The later study of Matsushita has shown that the upper part (200m) of Ikebe's Shidôgû is to be included in the Kuken.

The Shôgen System is distributed also in the Kangtong district in the northeast part of the mapped area and in the district to the northeast of Phyongyang. According to Matsushita's research, the Shôgen of the above-mentioned districts is divided as follows.

Kuken Series		200 m
Shidôgû Series	6. Thin platy crystalline limestone	100
	5. Slate or *Collenia* limestone	10
	4. Dolomite	200–300
	3. Thin platy limestone	200
Chokken Series	2. Green phyllite	500
	1. White quartzite	5–50

Formation 1 overlies unconformably the mica-gneiss. 2 intercalates white crystalline limestone. 4 emits H_2S odour, when struck by a hammer. 5 is useful as a key bed. 6 is also a characteristic bed, white or brownish white in colour.

The Kuken Series consists of black slate with the intercalation of siliceous slate or quartzite and lenticular white crystalline limestone. In the Kangtong district, as well as in the Shôgen district, one to several sills of diabase with a thickness of several to several tens of meters frequently occur in the Kuken Series, especially in its upper part.

In the northeast corner of the mapped area the Kuken Series is absent. This may be interpreted to have been denudated before the deposition of the Chôsen System. In the district to the northeast of Phyongyang, the upper two beds of the Shidôgû Series (5 and 6) are not seen. This fact might have been caused by a thrust. The Kuken Series in the district to the northeast of Phyongyang dips southeast monoclinally. It is interpreted that the series forms an isoclinal folding.

In the western half of the mapped area, the Shôgen System occurs as narrow patches inserted by thrusts or along a thrust and only the Kuken Series occurs.

The Kuken Series in the district of Songyong-myon and Pansyok-myon consists of phyllite and is folded with an axis of NE-SW direction.

The Kuken along the Mukakusan thrust is composed of green phyllite intercalating lenticular grey white crystalline limestone.

As stated above, the Shôgen System of this region is developed in its eastern half. But the total thickness of the system is estimated at 1,700 m in the Shôgen district and 1,500 m in the Kangtong district and the area to the northeast of Phyongyang, so that the Shôgen of this region is much thinner than that of the central part of Hwanghae-do (Kôkai-dô) which is more than 7,000 meters thick.

The correlation of the Shôgen System of the Kangtong district and the district northeast of Phyongyang with that of the central part of Hwanghae-do is tabulated below.

Kangtong district and the district to the northeast of Phyongyang			Central part of Hwanghae-do		
Kuken Series		200 m	Kuken Series	1500 m	
Shidôgû Series 510–610	Thin platy crystalline limestone	100	Gyokukenri siliceous limestone	50–330	Shidôgû Series 2000–2400
	Slate or *Collenia* limestone	10	Sekkazan slate	250–450	
	Dolomite	200–300	Seisekitô limestone Tokuzai dolomite	450–600 250–540	
	Thin platy limestone	200	Ginseki limestone	700–1000	
Chokken Series 505–550	Green phyllite	500	Anshinrei calcareous phyllite	625+	Chokken Series 3100–3800
	White quartzite	5–50	Chôjuzan quartzite	1000+	
			Gohôri slate	500–1800	
			Shôhô feldspathic quartzite	600–1000	

As shown in the table, the difference in thickness is recognized not only as a whole, but also in each formation. It must be noticed that the Chokken Series of this region is correlated with the upper part of the Chokken of central Hwanghae-do. The Shôgen System is absent in the region south of Hwanghae-do. From these facts, Matsushita has inferred that the geosyncline in which the Shôgen was deposited was extended nearly in the E-W direction and that the south part of Hwanghae-do was at the median axis of the geosyncline and South Pyongam-do was the north part of the geosyncline, and that the deposition proceeded, overlapping northward.*

Chôsen (Tyôsen) System

The Shôgen System is overlain with a slight clino-unconformity by the Cambro-Ordovician Chôsen System, of which the lower areno-argillaceous part is called the Yôtoku Series and the upper calcareous part is named the "Great Limestone Series." In 1936 Nakamura proposed the name of Chûwa Series as the substitute for the Yôtoku Series to be used

---

* In respect to the unconformable contact between the Shôgen System and the Kokulian Granite, Matsushita now entertains some doubts. Refer to the following articles:

Matsushita, S. (1947), Studies on the Sinian System. Mem. Coll. Sci., Kyoto Univ., Ser. B, Vol. XIX, 1.

,, (1952), Pre-Cambrian. (In Japan.) Historical Geology I, Tokyo.

,, The Sinian System in North China, South Manchuria and Korea with Special Reference to its Relation to the Cambrian. Contributed to the Symposium on the Cambrian at the XXth International Geological Congress in Mexico in September 1956.

in the case of fossiliferous formation in the neighbourhood of Phyongyang.

(a) Yôtoku* (Chûwa) Series

This lower Cambrian series was divided by Nakamura in 1936 as follows.

Yôtoku (Chûwa) Series { Shôra Stage { Masanri bed, Rakumin bed ; Monsanri Stage }

The Monsanri** Stage composed of conglomerate, shale, limestone, quartzite, though variable in rock facies and thickness, is present almost persistently throughout the whole region under consideration as the basal part of the Yôtoku Series. A lower Cambrian trilobite *Protolenus* was first found in 1932 in the Monsanri, at Kuken (Kuhyön) to the immediate south of the mapped area (K. Saitô, 1933 a, b), and afterwards at the east of Fukkyo (Kokkyô) and at the east of Hwangju (Kôshû), but it has not been discovered yet in the present mapped area.

The Shôra Stage named after the name of a small hill near the Jidô coal mine is divided into the Rakumin bed and the Masanri bed. The Rakumin bed consists mainly of shale and contains the characteristic lower Cambrian trilobite *Redlichia*, while the Masanri bed is composed of sandy shale, containing trilobites *Ptychoparia* and *Anomocare*. In both beds are intercalated lenticular limestones. At the top of the Masanri bed there is several meters of a quartz-sandstone bed which Nakamura called the Fukadani sandstone in 1936.

The Yôtoku (Chûwa) Series is widely distributed in the Chûwa-Shôgen district and constitutes the hilly land to the east of the Kangtong town and that to the northeast of Phyongyang. Besides, it often occurs, forming narrow belts, namely on the northeast side of Tolpaksan (Sekihakusan) hill north of Phyongyang and on the southeast side of the Jidô thrust running from SW to NE. Further it forms narrow belts between the Kinsai and Chôzan thrusts and along the Mukakusan thrust.

The Chûwa Series of the Tyunghoa (Chûwa)—Pisyokkol (Hisekidô)—Syangwon (Shôgen) district was studied first by Nakamura in 1925, afterwards by the late K. Saitô and still later by Ikebe (Nakamura, 1926; Saitô, 1933a; Ikebe, 1939). In the neighbourhood of Chûwa, the Monsanri Stage is divided in descending order as follows:

Monsanri quartzite ....150 m.
(white sandy quartzite or siliceous sandstone)
Alternation of the above-mentioned quartzite and bright red brown shale }
Bright red brown shale } 30 m.

* Yôtoku (Yangdok after the Korean pronounciation) is the name of a town in the east part of S. Pyongam-do, situated about 100 km east of Phyongyang measured in a straight line.

** Monsanri is the name of a small village situated 7.5 km, measured in a straight line, northwest of Shôgen.

Saitô called the Rakumin bed the *Redlichia* shale bed, and divided it into the upper (350–450 m) and the lower (about 150 m), assuming the boundary at the base of a sandstone. The lower *Redlichia* shale bed is composed of dark green, sometimes purplish shale, intercalating limestone (often oolitic, seldom pisolitic). The fossils from the shale are: trilobite *Redlichia chinensis* Walcott, *Redlichia nobilis* Walc., brachiopod *Acrotreta* sp., *Obolella* sp., *Lingulella* sp., and the pisolite in limestone is a calcareous alga *Girvanella manchurica* Yabe et Ozaki.

The upper *Redlichia* shale bed consists mainly of red purple or brown sandy shale, intercalating limestone which often yields *Girvanella manchurica*. The upper *Redlichia* shale bed is divided into the following fossil zones arranged in descending order.

d. Non-fossiliferous bed............alternation of purple shale and thin sandy shale.
c. *Dorypyge* cf. *tokunagai* Zone.
b. *Redlichia* cf. *walcotti* Zone.
a. upper: *Redlichia nakamurai* Zone.
   lower: *Redlichia coreanica* Zone.

According to Ikebe, the stratigraphy of the Yôtoku Series in the Shôgen district is as follows. The Monsanri Stage is divided into the lower, purple red claystone (less than 10 m thick) and the upper, Monsanri quartzite (white platy quartzite, 3–10 m thick). The purple red claystone intercalates iron ore beds. In some cases the purple red claystone is absent, and the Kuken Series or the greenish diabase sheet is overlain directly by the Monsanri quartzite. The rocks of the Shôra Stage of the Shôgen district are somewhat metamorphosed, and seldom bear fossils, so that it is not possible to distinguish clearly the Rakumin bed from the Masanri bed. The Shôra Stage, about 400 m thick, is composed chiefly of green slate in the lower part and the flaggy slate in the upper part.

The Yôtoku Series distributed in the districts to the east and southeast of the Kangtong town is also divided into the Monsanri and Shôra stages. The Monsanri Stage consists of 20–25 m of white quartzite (Monsanri quartzite) alone, the underlying shale lacking. Below the Monsanri quartzite of this district is seen almost everywhere an intrusive sheet of diabase 20–40 m thick. The diabase sheet exists also in the Kuken Series itself, accordingly this sheet is inferred to have been injected into the Kuken Series before the deposition of the Monsanri quartzite.

The Shôra Stage, about 350 m thick, is composed of green grey (when fresh, light greenish blue) phyllite, intercalating lenticular white crystalline limestones. The phyllite is being used as a roofing slate.

The Yôtoku Series in the district northeast of Phyongyang is also composed of somewhat metamorphosed rocks and contains no fossil. The Monsanri Stage is represented by the Monsanri quartzite which is 20–25 m in most cases, more than 100 m in some cases and almost absent in other cases. The Shôra Stage is composed of green phyllite, sometimes intercalating lenticular limestones which are commonly several meters and sometimes 50 m thick, and white, crystalline or blue grey, compact. The Yôtoku Series dips southeast apparently monoclinally at 20-40°, but the Shôra Stage seems to be isoclinally folded, and so the true thickness is unknown.

The hills of Wontan-myon village in the Kangtong county is composed mostly of the Yôtoku Series. The Monsanri quartzite is very thin, less than 3 m thick. The Shôra Stage consisting of green phyllite dips southeast at about 40°.

The Yôtoku Series exposed at the hill Tolpaksan to the north of Phyongyang was studied by Maejima and Takimoto in 1936. The Monsanri Stage is divided into the basal bright red, yellow green shale and the Monsanri quartzite, the latter of which, though only several meters thick, is apparently composed of many beds, on account of intense folding. The Rakumin bed begins with yellow slate in which the cleavage perpendicular to bedding plane is well developed, and changes upward to sandy and micaceous rock, and then to brown shale. The last-named rocks passes gradually into the overlying Masanri yellow shale, and then upward, through micaceous red sandy shale, to sandstone, next thin grey green micaceous siliceous sandstone, further to thin yellow slaty shale. The top of the Masanri bed is represented by the Fukadani sandstone which is 5 m thick, grey white or light yellow, hard, compact quartz-sandstone.

On the southeast side of the Jidô thrust, the richly fossiliferous Chûwa Series is distributed, forming a narrow belt. According to Sakakura's study, there is neither Kuken Series nor Monsanri Stage in this area. Following Saitô who studied the Cambrian of the Tyunghoa district in 1933, Sakakura divided in 1936 the Shôra Stage into the *Redlichia* shale and the *Ptychoparia* bed. The former consists of chocolate-coloured shale and sandy shale, accompanied by brown sandy shale or sandstone. The fossils from the *Redlichia* shale are:

Redlichia chinensis Walcott
R. nobilis Walcott
R. coreanica Saitô
Obolus cf. *detritus* Mansuy
Botsfordia cf. *granulata* (Redlich)
Acrotreta coreanica Saitô.

The top of the *Redlichia* shale is represented by a deep chocolate-coloured compact shale with one life-zone bearing *Redlichia* sp. indet., *Obolus* cf. *detritus*, *Botsfordia* cf. *granulata*.

The overlying *Ptychoparia* bed with a thickness of about 350 m is composed of purple, grey green and brown sandy shale. Two life-zones are recognized in this bed. The lower zone composed of limestone is called *Eodiscus fusifrons* zone with *Eodiscus fusifrons* Saitô, *Proliostracus* ? *brevicaudatus* Saitô et Sak. while the upper one, called the *Proliostracus* ? *brevicaudatus* zone is a yellow grey or yellow green shale bed, about 10 m thick in the upper part of the bed. The following fossils have been reported from the upper zone.

Proliostracus ? *brevicaudatus* Saitô et Sakakura
Pinaspis kodairai Saitô et Sakakura
Oryctocephalus orientalis Saitô
Agnostus rakuroensis (Kobayashi)
Dolichometopus sp.
Bradoria sp.
Obolus sp. indet.
Lingulella sp. indet.
Botsfordia cf. *granulata* (Redlich)

The Yôtoku Series occurs on the western margin of the Phyongyang Coal Field, forming narrow belts between Kinsai thrust and Chôzan thrust and along the Mukakusan thrust (Pl. XV). According to Ikebe, the stratigraphic sequence of the Yôtoku Series in this area is as follows. The Monsanri Stage, 10 m thick, consists of quartzite and siliceous slate, and the Rakumin bed is 60 m of green slate in which *Redlichia* sp. indet. was found. The Masanri bed is a micaceous sandy shale bed with a thickness of 50 m, of which the uppermost bed, 5 m thick, is the Fakadani sandstone.*

(b) "Great Limestone Series"

Except the basal shale part, several tens of meters thick, called the Rinson shale or Rinson Stage, this series is composed exclusively of limestone and dolomite with a thickness of more than 1,000 m, underlying para-unconformably the Heian System, the most important formation of the Phyongyang Coal Field.

Formerly the division of this series was not definite. And so, based on the result of Ikebe's research on the geology of the Shôgen-Santo district, Nakamura classified in 1938 (Ikebe, 1939), "the Great Limestone Series" as follows:

Bantatsu Series	Kôjinsan Stage	Middle	Ordovician
	Madenpo Stage	Lower	
Kôreisan Series	Kôteisan Stage	Upper	Cambrian
	Rinson Stage	Middle	

The Rinson Stage, several tens meters thick, consists of black (when

* Fukadani is the name of an old abandoned pit near the A colliery of the Kôsai coal mine.

weathered, green grey) shale, intercalating limestone, and is often rich in fossils of trilobite and brachiopod. Thus this stage is a conspicuous bed and very important as a key bed. Both Kôteisan Stage and Kôjinsan Stage are of limestone (as an exception, the uppermost part of the Kôjinsan Stage is sometimes dolomite), while the Madenpo Stage is of dolomite (Pl. II & III). The Kôteisan and Madenpo Stages yield fossils rarely, whereas rich fossils of cephalopod and gastropod etc. are often found in the Kôjinsan Stage.

The stratigraphy of "the Great Limestone Series" of the Chûwa district is, according to Saitô, as follows (Saito, 1933a). The Rinson shale is 80-120 meters of black shale, not seldom bearing lenticular limestones.

The fossils are found in limestone as well as in shale. The most characteristic fossils are *Acrotreta* aff. *shantungensis* Walcott, *Agnostus chinensis* Dames, *Dorypyge richthofeni* Dames, *Elrathia chuwaensis* Kobayashi (=*rinsonica* Saitô) which are accompanied by many other trilobites and brachiopods.

The overlying limestone formation is apparently more than 100 m thick, and is divided in descending order into dark grey massive limestone (with ceplalopod fossil *Liospira* cf. *lenticularis* Kobayashi), grey white dolomite and dark grey massive limestone.

"The Great Limestone Series" of the Syangwon (Shôgen)—Samtung (Santo) district, as mentioned above, was studied by Ikebe (Ikebe, 1939). The Rinson Stage consists of black (when weathered, light green yellow) shale in the Shôgen district, and of black slate in the Santo district. In both districts are intercalated in the stage lenticular grey white or black platy limestones with a thickness of 10-20 m in most cases, 2-3 m in some cases. The overlying Kôteisan Stage, 350-500 m thick, is composed of black thin platy limestone which is sometimes accompanied by dark grey massive dolomitic limestone in the basal part.

The Madenpo Stage with a thickness of 300-400 m is mainly composed of dolomite, accompanied by the alternations of dolomite and limestone, or dolomitic limestone in the upper part. Sometimes the lowest part is accompanied by black thin platy limestone from which are found cephalopod *Coreanoceras*, *Cyrtoceras*, and gastropod *Holopea*. These fossils may indicate that the Madenpo Stage is an equivalent of the lower Ordovician Shôrin bed in the vicinity of Kenjiho.

The Kôjinsan Stage is 200-250 m thick. Its lower part is a blue grey thin platy limestone, and the upper part is a blue grey cloudy limestone. Ikebe obtained a sponge fossil which he named *Receptaculites coreanicus* Ikebe MS from the cloudy limestone at a point 1.4 km south of Santo. The Kôjinsan Stage belongs to the Toufangian (middle Ordovician). The uppermost part, 5-20 m thick, of the Kôjinsan Stage consists of dark grey massive dolomite, and was named the Shôgairi Stage by Ikebe.

In the Sungholi (Shôkori)—Mantalsan (Bantatsusan) district is widely distributed "the Great Limestone Series", of which the stratigraphy and fossils were studied by Kobayashi. In this district only the Bantatsu

Series occurs, Kôreisan Series being absent. The Bantatsu was divided by Kobayashi as follows (Kobayashi, 1929, 1930a).

Nansô formation Unkaku formation	……………… Kôjinsan Stage
Bantatsusan formation Kôsei formation	………… Madenpo Stage

The Madenpo Stage consists largely of blackish grey or grey, compact or crystalline dolomite, sometimes intercalating thin layers of limestone. The dolomite often contains thin layers and nodules of black chert, of which weathered lime-lost part was once worked as a ganister.

Fossils are seldom found in the Bantatsusan formation. Cephalopod *Stereoplasmoceras* cf. *pseudoseptum* Grabau together with imperfect fossils of brachiopod and gastropod was reported by Kobayashi.

The Kôjinsan Stage, 450 m thick, is composed of black platy limestone and cloudy limestone, sometimes intercalating grey dolomitic limestone. The limestone of this stage is used as material for cement. The lower part of the Kôjinsan Stage, namely the Unkaku formation yields rich fossils. The following fossils were reported by Kobayashi.

Gastropoda

Buccania katoi Kobayashi
Lophospira acuta Grabau
L. kodairai Kobayashi
L. konnoi Kobayashi
L. subpulphella Kobayashi
L. bantatsuense Kobayashi
L. morrisi Grabau
L. gerardi Grabau
L. trochiformis Grabau
Pagodispira tetracarina Kobayashi
Liospira barbouri Grabau
Eotomaria concava Kobayashi
Ophiletina sp. indet.
Oph. ? *shokoriense* Kobayashi
Eccyliopterus kushanensis Grabau
Helicotoma yabei Kobayashi
H. tamurai Kobayashi
Trochonema ozawai Kobayashi
Tr. ozawai depressa Kobayashi
Maclurea tofangoense Kobayashi

Cephalophoda

Vaginoceras sp. cf. *Vaginoceras multitubulatum* (Hall)
Cameroceras sp. indet.
Cycloceras mantalense Kobayashi

C. kawasakii Kobayashi
Stereoplasmoceras pseudoseptum Grabau
S. submarginale Kobayashi
Actinoceras richthofeni Frech
A. submarginale Grabau
A. manchurense Kobayashi
A. exogastrale Kobayashi
Ormoceras tani (Grabau)
O. nanum (Grabau)
O. suampanoides (Grabau)
O. harioi (Kobayashi)

It has been found from the above-cited fossils that the Unkaku, Bantatsusan and Nansô formations belong to the Toufangian (middle Ordovician). Stromatoporoid fossils *Labechia shansiensis* Yabe et Sugiy., *L. regularis* Y. et S., *L. regularis tenuis* Y. et S. were reported found from the north foot of Mt. Mantalsan by Yabe and Sugiyama (1930b).

,,Teh Great Limestone Series'' is distributed also in the Kangtong (Kôtô) district, but no fossils have been reported to occur. The Rinson Stage, 10-30 m thick consists of black slate accompanied by thin platy limestone. The Kôteisan Stage with a thickness of 320 m consists of dark grey or light grey thin platy, sometimes thick platy limestone. The Madenpo Stage consists of dark grey or light grey, fine-crystalline dolomite which emits H_2S odour, when struck by a hammer. The overlying Kôjinsan Stage is composed of blue grey platy limestone and cloudy limestone.

"The Great Limestone Series" of the district to the northeast of Phyongyang is similar to that of the Kangtong district.

"The Great Limestone Series" occurs at the north of the Kanpoku coal mine too. According to Maejima and Takimoto (1937), the Rinson shale is some 30 m thick grey yellow shale, rarely yielding trilobite *Ptychoparia kochibei* Walcott.

The Rinson shale and the overlying limestone are distributed also on the southeast side of the Jidô thrust. The Rinson shale is about 150 m thick, grey green or green black shale with non-fossiliferous lenticular limestones. Many fossils of trilobite and brachiopod are found in the shale. Sakakura (1936) reported the followings; *Elrathia chuwaensis* Kobay., *Agnostus rakuroensis* Kobay., *Ptychoparia kochibei* Walc., *Dorypyge* sp., *Anomocare* sp., *Obolus* sp., *Lingulella* sp., *Acrotreta* sp., *Protospongia* sp.

Between the Kinsai thrust and Chôzan thrust also, "the Great Limestone Series" is found elongated in the NE-SW direction. The Rinson shale and the overlying limestone are 30 m and 800 m thick respectively.

Near the A pit of the Kôsai coal mine is exposed only the Rinson shale of "the Great Limestone Series," owing to the Ryûsei thrust. The limestone of the Koteisan Stage is found along the Ryûsei thrust at the deeper part of the incline of the mine. Trilobite fossils *Ptychoparia*, *Agnostus* and *Anomocarella* have been found in the shale.

Heian System

The Upper Palaeozoic formation of Korea is the Heian System. It is generally accepted that this system is composed of the following four series:

4 Greenstone Series
3 Kôbôsan Series
2 Jidô Series
1 Kôten Series

but it seems more suitable to divide the Jidô Series into two parts, the Upper and the Lower Series, because the lithologic and facies characters of these parts are markedly different from each other. We propose therefore the following five series of the Heian System.

(a) Kôten Series

This is the basal group of the Heian System and lies on the middle Ordovician limestone of the Chôsen System with a parallel unconformity. The whole series is characterised by variagated rocks.

1. The base of this series is a brown, red and purple mudstone or shale which often intercalates micaceous or arenaceous part (the Alnemi shale named after the name of a pass, east of Hoachonli—Kasenri). Locally as in Samtung (Santo) the basal conglomerate of dolomite gravels occurs. The pisolitic hematite bed is contained in the basal part and sometimes forms workable iron deposit as seen in Kongpho-myon (Kôho-men).

2. On the basal part, several metres thick, there comes a group mainly composed of grey white limestone and chert, with some thin purple-red shale.

3. The group 2 is succeeded by the alternations of dark or reddish purple micaceous shale and sandstone, but the colour changes to dark green, greyish black or greyish yellow and sometimes white quartzose sandstone becomes predominant. In the area including Samtung and Kangtong (Kôtô) where regional metamorphism is remarkable, dark green ottrelite is characteristic in green or yellowish grey slate.

4. The uppermost part of the series is again the alternations of grey white limestone and chert with some variagated shales.

The above-mentioned sequence is established as the standard in the eastern part of the coal field and there are of course local differences. Generally speaking, the development of limestone and chert zones becomes worse towards west and reddish or yellowish shale is prevalent and only two or three lenses of limestone or chert are traced. Besides, on the hills south of Yonghoani (Renkari), Sityok-myon (Shisoku-men), the Kôten Series is represented by thick reddish shales with patches of light green colour, some aluminous shale in the basal part, and limestone is very poor.

Throughout the coal field rich marine fossils have been reported while the plant fossil is poor, only a fragment of a pinnule of *Neuropteris* having been found at Pultangkol (Butsudôdô), Sityok-myon (Kobatake 1954). From the basal part (probably equivalent to the Alnemi Shale) of the same locality Ozaki (1934) reported the following brachiopods:

Lingula sp.
Rhipidomella cf. *cora* d'Orb.
Streptorhynchus ? sp.
Chonetes cf. *carbonifera* Keyserl.
Schizophoria swallovi (Hall)
Productus 2 spp.
Spirifer (*Choristites*) *pavlovi* Stuck
Spirifer 2 spp.

The same fauna has been found also in the Samtung district and *Chonetes* cf. *carbonifera* occurs near the Chôzan (Tyangsan) coal mine.

Yabe and Hayasaka (1915) have identified the following corals:

Chaetetes asiaticus Yabe et Hay.
Caninia muratai Yabe et Hay.
C. sp.
Cystophora dubia Yabe et Hay.
C. kikkawai Yabe et Hay.
Arachnastraea coreanica Yabe et Hay.

According to Yabe (1919), these fossils were collected from the limestones in the Taisei district together with *Pseudoschwagerina glomerosa*, but our field survey has revealed that these corals and *Pseudoschwagerina glomerosa* occur in distinctly different horizons, the latter in the Lower Jidô Series.

Beside corals, *Spirifer* sp. and *Productus* sp. have been found from limestones in the same area and a small gastropod in the limestone near Tumukol (Tomudô), Sityok-myon (Kobatake 1953).

The most important fossils of the series are fusulinids and studied by many authors and Hatae summarized the following elements of the fauna in the east coal field (1939). Fossils obtained in the Koten Series are summarized as follows (Huzimoto 1938,* Hatae 1939):

Textularia obusa Huzimoto
T. eximia Echw.
T. exidura Lee
Cribrostomum textulariforme Möll.
C. commune Möll.
C. exmium (Eichw.)
C. bradyi Möll.
C. nelumboforme L. et C.
Climacammina antigua Brady
C. patura (Brady)

* Huzimoto reported that the fossils were collected from "*Schwagerina princeps*" zone, but the limestones, from which he obtained these fossils, do in reality not always belong to this zone at Sadong.

C. maxima (L. et C.)
Monogenerina cf. *gradata* Lange
Bigenerina geyeri Schellw.
B. cucumis Lange
Bradyina rotula Eichw.
B. nautiliformis Möll.
Endothyra bowmani Phill.
Ozawainella loczyi (Lör.)
O. angulata (Coloni)
Staffella confusa L. et C.
S. ozawai L. et C.
S. sphaeroidea (Ehr.)
Boultonia wilssi Lee
Fusulinella obscura (L. et C.)
F. compressa Ozawa
F. parva L. et C.
F. pseudobocki (L. et C.)
F. pseudobocki var. *zidôensis* Huz.
F, rhomboides (L. et C.)
Fusulina cylindrica Fisch.
F. quassicylindrica L. et C.
F. pankouensis Lee
F. konnoi Ozawa
Tetrataxis conica Ehr.

Fragments of crinoid stems are also characteristic in chert bed, but they are not yet fully studied. Though the species and exact horizon are unknown and reliability is doubtful, it is worthy of notice that in the western coal field fresh-water shells were reported to occur abundantly in this series (Kon'no 1928).

The geological age of the Kôten Series is assumed to be Moscovian from the fossils and is correlated with the Penhsi Series of South Manchuria and North China.

(b) Lower Jidô Series

This series lies on the Kôten Series with a disconformity, but it is difficult to recognize this relation in the field, as in most cases the two series contact with each other with thrust or fault. The lack of the Uralian has been ascertained by the foraminiferal studies and the abrupt change of the lithological characters seems to suggest strongly the existence of disconformity between these series.

The series are the alternating black shales and sandstones with lenticular intercalations of black limestone and hornstone. The upper limit of the series is the uppermost black limestone with *Pseudoschwagerina glomerosa* Depr. and black hornstone belts. This limestone, though lenticular, always appears at the same horizon usually accompanying a coal seam below. This is, however, often replaced by black hornstone zone. Three coal seems are found in the Lower Jidô Series, but none of them are worked except at the Kôsai colliery.

Various fossils have been reported from this series, in which fusulinids are most important. The summation of the studies is as follows (Hatae 1939)**:

Textularia eximia Eichw.
T. exidura Lee
Cribrostomum maxima L. et C.
C. eximium (Eichw.)
C. nelumboforme L. et C.
Cribrogenerina bradyi Möll.
Climacammina maxima L. et C.
Bigenerina geyeri Schellw.
Bradyina rotula Eichw.
B. nautiliformis Möll.
* *Endothyra bowmani* Phill.
* *Ozawainella loczyi* (Lör.)
* *O. angulata* (Colani)
* *S. sphaeroidea* (Ehr.)
* *Fusulinella parva* L. et C.
* *F. obscura* (L. et C.)
* *F. rhomboides* (L. et C.)
* *Fusulina konnoi* Ozawa
Schwagerina alpina (Schellw.)
S. subcylindrica Depr.
S. cf. *richthofeni* Schellw.
S. cf. *incisa* (Schellw.)
S. cf. *gallowayi* (Chen)
Quasifusulina tenuissima (Schellw.)
Q. longissima (Möll.)
Pseudoschwagerina glomercsa (Depr.)
Tetrataxis conica Ehr.
T. decurrens (Brady)
T. schellwieni Ozawa
Stacheia sp.
Lagena sp.

Of these foraminifera *Pseudoschwagerina glomerosa* is the leading fossil

** The species with asterisk in this list are at present believed exclusively of Moscovian, so it is doubtful whether they coexisted with lower Permian species, or the materials from different horizons or localities were wrongly treated as from the same horizon.

of the series in the field.

On the other hand, Yabe (1919) reported the following brachiopods from the *Pseudoschwagerina* zone:

Productus sp.
Uncinulus sp.
Dalmanella sp.

and from the same zone Ozawa (1927) reported:

Schizophoria cf. *juresanensis* Tschern.
Productus sp
Retzia sp. (?),

and Ozaki (1935) described

Pleurotomaria sp.
Zygopleura sp.
Worthoniopsis sysranica Stuckenb.
W. sp.,

Corals such as

Caninia sp.
Cystophora sp.
Arachnastraea sp.

were collected by Yabe (1919).*

From the sandy shale of Tyonsan of the Kôbôsan colliery a gastropod and *Productus* were obtained (Kobatake 1953).

The geological age of the Lower Jidô Series is Sakmarian and correlated with the Huangchi Series of South Manchuria and the Taiyuan System of North China.

The total thickness is 150 m at most.

(c) Upper Jidô Series

This is the most important formation of the Phyongyang (Heijô) Coal Field, as the main coals are preserved in this series, and lies conformably on the Lower Jidô Series. Grey black shales and dark grey or whitish grey micaceous sandstones are the main constituents and no limestone nor hornstone is intercalated. The boundary between the overlying Kôbôsan Series is drawn where the black shales contact with the

---

* When Yabe's report on the geological survey of the coal fields of South Phyongandô was published in 1919, he included the *Pseudoschwagerina* zone in the Kôten Series and fossils were treated as such and this thought had been followed for long time after. Now that *Pseudoschwagerina glomerosa* is considered a leading member of the Lower Jidô Series, it is a pending question whether these brachiopods and corals coexist with *Pseudoschwagerina* or not, because there seems to have been possibility that at that time fossil materials of the Kôten and the Jidô Series were treated together as from the same horizon.

yellowish grey rocks, but it is often the case that thick white quartzose sandstone, the Chôzan Sandstone (Ikebe 1935) for instance, appears in this horizon, and so it may be convenient to look on this sandstone as the base of the Kôbôsan Series (Pl. XVI, Pl. XVII, fig. 1). The lithological characters of sandstone and shale are not different from those of the Lower Jidô Series, but there is a striking contrast between the colour of this series and that of the Kôbôsan. Sandstones are fine- or medium-grained and developed generally in the middle of the series. In the Kôbôsan district both middle and upper parts of the series are rich in sandstones.

Belts of aluminous shale often occur as the underclay of the uppermost coal seam and when thick, it is worked for the material of fire brick, as at the Kampoku (Kampuk) mine.

Some mentions about the coal will be given here. The coal of the Heian System is anthracite and preserved in the Kôten, Jidô and the Kôbôsan Series, but all workable seams are in the Upper and the Lower Jidô Series. The coal in the Kôten Series is of trace and in the Kôbôsan Series two or three seams exist in the lower part and some of them have thickness of 1 m as in the Kôbôsan district but most ones are thin, uncontinuous and of worse quality.

Shiraki has distinguished 4 groups of coal seams in the Jidô Series in ascending order from A to D, of which A and B belong to the Lower, C and D to the Upper Jidô Series. Every group consists of several seams, for example, B contains 2 seams, C 3 and D 4. Quite similarly as in the other coal fields of Korea, in the Phyongyang (Heijô) district, it is very difficult to correlate the individual coal seam of a mine with that of the other collieries. This is mainly because the preservation of anthracite depends largely on the tectonic structure of the region. As already pointed out by Matsushita (1937), coal had been crushed and powdered by the crustal movement and moved along the bedding plane or flowed into the fractures just as the fluidal matter. Especially the shifts along the thrust or fault planes are remarkable and in the case of folding, coal in the wings was ready to be squeezed towards the crestal parts of the anticline or syncline where large coal reservoirs or pockets are often found. Therefore the coal seam, originally in the same thickness, irregularly became thicker or thinned out or branched into several seams and in the coal mine they are worked as different, for instance, the upper, middle and lower seams. Such behaviour of the coal resembles the intrusion of magma and Matsushita proposed (1937) the term "coal vein" for these anthracite seams.

Intrusions of porphyrite and lamprophyre into the coal seams are often met with throughout the coal field and thereby the coal became hard and massive and very scanty of volatiles.

The table below indicates the tentative correlation of the coal seams worked in the collieries of the Heijô Coal Field, but owing to the above-mentioned reasons, the table of course will be corrected after the result of the further research.

Colliery	Coal Horizon								
	D			C			B		A
Kôsai									
B									
A			×	×		×	×		
Taihô									
Chôzan	×	×					×	×	
Honkô	×	×			×	×			
Daimonsan			×	×	×				
Teihaku			×	×					
Jidô	×	×			?				
Kampoku									
Miroku					×	×			
Honkô	×	×							
Kôbô	×	×			×				
Sanshin									
Takamine					×				
Sanshin					×				
Seiryû							?		
Gentan									
Baidô	×	×							
Hôwô					×				
Nankin					×				
Taisei									
Daisô	×	×							
Ryûko	×	×							
Momodani					×	×			
Santo									
Kokurei				×					
Shôgairi					×				
Tokusan						×			
Kôtô									
Garyûri			×	×					
Kohiri					×				

Most fossils of this series are plants found in accompany with coal seams of the upper group and the fossil horizon is bed D established by Shiraki (1940) in the Samtyok (Sanchoku) Coal Field, South Korea. The only marine animal is *Aviculopecten*, collected by Maejima at the Jidô mine and this is of importance for the inference of the environment of deposition of the series.

After Kawasaki (1927, 1931, 1932, 1934), Kon'no (1928, 1929) and others, the flora contains the following elements:

Calamites Suckowi Brong.

Annularia stellata Schloth.
A. orientalis Kawas.
Lobatannularia inequifolia Tokun.
Sphenophyllum oblongifolium Germ. et Kaulf.
S. orientale Kawas.
S. macrotruncatum Kawas.
S. pseudocostae Kawas.
S. macrophyllum Tokun.
S. Thonii Mahr
S. Thonii Mahr var. *minor* Sterz.
S. emerginatum Brong.
Pecopteris hemiterioides Brong.
P. oreopteridia (Schloth.)
P. Candolleana Brong.
P. polymorpha Brong.
P. tuberculata Halle
Pecopteridium manchuricum Kawas.
Callipteris conferta (Sternb.)
C. ascendens (Halle)
Callipteridium koraiense (Tokun.)
Alethopteris Norinii Halle
Mariopteris ? sp.
Odontopteris subcrenulata Rost.
Desmopteris Hallei Kawas.
Taeniopteris serrulata Halle
T. multinervis Weiss
T. mucronata Kawas.
Lepidodendron oculus-felis Abb.
L. orientale Koiwai
Sigillaria cf. *semipulvinata* Kidst.
Stigmaria ficoides Brong.
Cordaites Schenkii Halle
C. minor Kawas.
C. parvifolius Kawas.
Cordaianthus sp.
Tingia Hamaguchii Kon'no
Pterophyllum daihoense Kawas.
P. bipartitum Kawas.
Ginkgoites ? *daihoensis* Kawas. et Kon'no
Walchia sp.
Lagenospermum acutilobum Kawas.
Koraia koraiensis Ôishi
K. obtusa Ôishi

The geological age of the series is from lower to middle Permian and correlated to the Liutang Series of South Manchuria and the upper part of the Yuehmenkou Series and the Lower Shihhotze Series of Central Shansi.

Total thickness is measured at about 200 m.

(d) Kôbôsan Series

The type locality of this series is the Kôbôsan district, north bank of the Taedonggan, where thick grey yellowish shale fragments give the strange surface feature to the hills.

This is a thick formation of shales and sandstones. Shales are usually yellowish brown or grey in colour and some part contain oolitic siderite grains. In the eastern area the shales were metamorphosed to bear pinkish grey colour and thin slaty schistosity. Sandstones are white quartzose, sometimes with small pebbles of quartzite and in the middle part they are often grey micaceous. Individual sandstone belt is 2-3 m in thickness, but several of them together form a sandstone zone, especially predominant in the lower and middle parts of the series. These sandstones develop widely in the eastern area and at Huknongsan (Kokuryûsan) mass they make rigid ridges against erosion.

Near the base some aluminous shales occur in the Kôbôsan and Taisei districts and several coal seams are intercalated in the lower part, but they are out of the mining object.

A very characteristic flora had flourished during the Kôbôsan age and was studied by may authors (Kawasaki 1927, 1931, 1932, 1934, Oishi 1922, 1930, 1931a, 1931b, Kon'no 1928, 1929, Yabe 1922, Koiwai 1927, 1937, Kodaira 1924, Tokunaga 1913 etc.). The plant-rich horizons are 3 in the west and east fields, but many less rich beds can be traced everywhere.

The enumeration of the floral members are indicated below. They have been reported from several horizons, but we can regard them as elements of one flora.

Calamites sp.
Asterophyllites cf. *longifolius* Sternb.
Annularia papilioformis Kawas.
Lobatannularia heianensis Kodaira
L. inequifolia Tokun.
L. ensifolia Halle
Neocalamites Meriani Brong.
Phyllotheca cf. *australis* Brong.
Schizoneura striata Kawas. et Kon'no
S. polymorpha Kawas. et Kon'no
Sphenophyllum sino-coreanum Yabe
S. speciosum Royle
S. verticillatum Schloth.
S. grandifolium Kobat.
S. kôbôense Kobat.

Pecopteris orientalis Schenk
P. anthriscifolia Göpp.
P. lativenosa Halle
Neuropteridium koreanicum Koiw.
Callipteris? ascendens var. *tenuicaulis* Kawas.
Desmopteris orientalis Yabe et Ôishi
Palaeovittaria coreanica Ôishi
Chiropteris reniformis Kawas.
C. Kawasakii Kon'no
Conchophyllum Richthofeni Schenk
Gigantopteris Yabei Kawas.
G. nicotianaefolia Schenk
G. Lagrelii Halle
Taeniopteris cf. *Schenkii* Sterz.
T. macrospatulata Kawas.
Tingia elegans Kon'no
Tingiostachya tetralocularis Kon'no
Protoblechnum Wongii Halle
Baiera tenuistriata Halle
Rhipidopsis brevicaulis Kawas. et Kon'no
R. baieroides Kawas. et Kon'no
Plagiozamites longifolius Kawas.
P. oblongifolius Halle.
P. Nakamurai Kobat.

The Kôbôsan flora contains special East Asiatic elements in great percentage and can roughly be correlated with the flora of the Upper Shihhotze Series in Central Shansi. On the contrary, the main members of the Jidô flora are those of the European Permo-Carboniferous and correspond to the floral constituents of the Upper Yuehmenkou—Lower Shihhotze flora. In Central Shansi the floral change from the Lower Shihhotze to the Upper Shihhotze seems rather gradual, while there is a marked contrast between the Jidô and the Kôbôsan floras. Consequently we cannot but suppose the existence of an unconformity on the Jidô Series from the floral point of view, though it is very obscure in field observation. In South Manchuria Noda (1953) reported the slight unconformity between the Liutang and the Tsaichia Series of the Taitzuho System. The striking lithological contrast between the Jidô and the Kôbôsan Series seems to support, though negative, the existence of the same relation in Korea.

The geological age of this series is upper Permian, the Upper Shihhotze Series and the Tsaichia Series being correlated with this series.

The thickness of the series is measured at about 600 m at the maximum in this coal field.

(e) Taishiin Series (Greenstone Series)

The Greenstone Series was proposed to a group of greyish green shales and sandstones typically develop in the coal field of the northern part of South Pyongam-dô. In the Phyongyang Coal Field the corresponding group is called the Taishiin Series because its characteristic colour of the rock.

The type locality of the series is Taejawon (Taishiin), Wontan-myon (Gentan-men) and the series is distributed widely throughout the coal field.

This series lies on the Kôbôsan Series with slight unconformity and can be divided into three parts. (Kobatake 1953).

The Godô bed is the lower part. The basal conglomerate consists of whitish quartzose sandstone with pebbles of quartzite of medium size and very rarely of black shale. In the northwest part of the Taisei district, the group is remarkably well developed, becoming a group of sandstones more than 100 m thick, with intercalations of grey yellow, reddish, bluish grey shale belts. Above this comes a bed of alternations of dark green and reddish brown shales.

The Sanseiri bed, the middle part, is a group of thick shale and sandy shale of reddish brown colour and sandstone is rather rare. It is one of the characterstics of the series that shales of the lower and the middle parts contain calcareous nodules of finger-tip size, and this is the common character of the Greenstone Series of Korea.

The upper part is the Yôdô bed in which whitish grey micaceous medium standstone is prevailing, but this group crops out in narrow area in the type locality.

The above-cited division is applicable also in the west part of the present coal field.

The only fossil ever found in this series is a silicified wood, *Dadoxylon** (*Cordaioxylon*) sp. from the shale in the basal sandstone group at several places in the Taisei district (Kobatake 1953). It is 10-15 cm in diam. and some specimen is nearly 1 m long, and it seems unnatural to consider such a long material was derived from the lower bed.

The only fossil material to decide the geological age of the series is *Cordaioxylon* and this genus is thought exclusively Palaeozoic and from this point of view, the lower part of the Taishiin Series is at least the uppermost Permian, but the remainder ranges into the Triassic, and may be correlated with the Shihchienfeng Series of Central Shansi.

The total thickness attains to 650 m.

Daidô System

Along the north bank of Taedonggang (Daidô-kô), there develops a thick formation of standstone, shale and conglomerate, ranging from the lower Jurassic (probably upper Triassic in part) to the upper part of the

* Pl. XXIII, Figs. 1-4, identified by Shimakura.

middle Jurassic and the name Daidô System was given to it. Its main distribution is in the west coal field and Phyongyang City, and the east extension forms the Taesongsan (Taiseizan) massif.

In the east, this system is divisible into 4 groups (Kobatake 1953). The reddish brown or grey basal conglomerate lies on the older rocks with marked unconformity. The basement formations are the Chôsen, Shôgen and Gneiss Systems. The conglomerate is made of unsorted gravels and boulders of quartzite, gneiss, phyllite and rarely limestone, cemented with brown clayey matrix. The basal conglomerate, about 50 m thick, is overlain by a group of white quartz sandstone, 80 m thick, with cross-bedding and ripple-marks and intercalates thin black carbonaceous shales which contain some plant fossils. On this group there is a bed of alternating sandstones and shales, about 50 m thick, and 3 *Corbicula* zones are in it. The alternations lie with thrust on the lower group, but the slip seems to have occurred along the basal bedding plane of the alternation, so that stratigraphically there is least break of succession. The uppermost part is a thick black shale group, scarcely with sandstone and the thickness exceeds 200 m.

In the west area Ikebe divided this system into 2 large parts and every part again into subdivisions (Ikebe in Matsushita 1938).

The basal conglomerate of nearly the same character as that of the east, rests on the Heian System. The overlying groups of the lower division are those of black shale, quartz sandstone and again black shale in ascending order and the important plant horizons are in both the lower and the upper shale groups. Sometimes in the lower shale group anthracite and aluminous shale are found and from the upper part of the upper group *Hildoceras inouyei* Yok. was once said to have been obtained near the pit of the Taihô colliery, but it is very doubtful, as there is no marine sediments in this area and no such fossil was found thereafter. The subdivisions of the upper division are black compact shale, pebbly sandstone and medium sandstone. The shale (Tozanri Formation) contains *Corbicula* and *Estherites* abundantly.

The total thickness is measured at about 1300 m.

Maejima (1935) proposed to divide the Daidô System of the Phyongyang City and its neighbourhood into the lower or the Senken formation (700 m) and the upper or the Ryûkyô formation (600 m).

The basal conglomerate does not appear on the surface except a small outcrop at Chyuam (Shugan). The Senken and the Ryûkyô formations are conformable with each other, the former is the alternations of black shale and light bluish grey sandstone and from the lowest black shale rich fossil plants were obtained and a fossil fish from the sandstone. The rocks of the latter are bluish white sandstone, greyish green and black shales and the petrified forest found in the ground of the

Heijô Middle School is very interesting. This fossil trunk is *Phyllocladoxylon heizyoense* Shimakura and other silicified woods were found on the hills of Muktantae (Botandai) etc. and the species were described as:

Xenoxylon latiporosum Gothan
X. phyllocladioides Gothan
Cedroxylon cf. *regulare* Felix

Fossil plants of the system in this field are listed below.

Neocalamites Carrerei Zeill.
N. sp.
Equisetites ferganensis Sew.
E. cf. *Sarrani* Zeill.
E. sp.
Cladophlebis denticulata Brong.
C. haiburnensis Lindl. et Hutt.
C. Raciborskii Zeill.
C. nebbensis Brong.
C. kogendoensis Kawas.
C. nampoensis Kawas.
C. argutula Heer
Eboracia lobifolia Phill.
Clathropteris meniscoides Brong.
Laccopteris polypodioides Brong.
Marattiospis asiatica Kawas.
Coniopteris hymenophylloides Brong.
Taeniopteris spatulata Mac Cll.
Nilssonia Münsteri Presl
N. tenuicaulis Phill.
N. pterophylloides Nath.
Ctenis Yamanarii Kawas.
Pterophyllum sp.
Ginkgoites sibirica Heer
Baiera gracilis Bunb.
B. concinna Heer
B. Phillipsi Nath.
Phoenicopsis angustifolius Heer
P. speciosa Heer
Czekanowskia rigida Heer
Podozamites distans Presl.
P. lanceolatus Lindl. et Hutt.
Swedenborgia lata Kon'no
S. attenuata Kon'no
S. coreanica Kon'no
S. Onoyamai Kon'no
S. rigida Kon'no
S. rigida var. *acuminata* Kon'no

Table I Correlation Chart of the Daido System

Western Part of the Heijô Coal Field			Heijô City		Kampoku-Gabisan District		Inken District	Daiseizan District	
Kon'no 1928	Ikebe 1938		Maejima 1935		Maejima, Takimoto 1937	Kon'no 1931	Kon'no 1931	Kon'no 1931	Kobatake 1953
			Upper Sandstone Beds						
	Kûrôri Formation (Black shale)		Shale Beds	Ryûkyô Formation					
			Lower Sandstone Beds						
	Monken Conglomeratic Sandstone	Upper Part							
			Upper Shale Beds						
	Tozanri Formation (Black shale)		Upper Sandstone Beds						
			Lower Shale Beds	Senken Formation	Upper Sandstone Beds				Roseiri Shale
Upper Shale Group	Gyokkahô Formation Upper part (Alt. of ss. & sh.)				Lower Shale Beds	Roseiri Black Shale		Roseiri Black Shale	
Quartz Sandstone Group	Saisekisan Sandstone Beds	Lower Part (Gyokkahô Formation)	Lower Sandstone Beds						Kaiundô Alternations
Lower Shale Group	Gyokkahô Formation Lower Part (Alt. of ss. & sh.)				Lower Sandstone Beds	(Thrust)	Daijôshi Sandstone	Daijôshi Sandstone	Daiseizan Sandstone
			(Fault)		(Fault)		Daiseizan * Basal Conglomerate	Daiseizan Basal Conglomerate	
Basal Conglomerate Group	Basal Conglomerate		Shugan Conglomerate		Basal Conglomerate	Daiseizan * Basal Conglomerate			Zudaji Conglomerate
Heian System	Heian System		?		Heian System	Heian System	Heian System	Gneiss, Shôgen, Chôsen Systems	Gneiss, Shôgen Chôsen Systems

* Kon'no's Inken light-coloured shale formation, which he thought the lowermost part of the Daidô System, is decidedly the Kôbôsan Series.

Pityophyllum longifolium Nath.
Spirangium sp.
After Kawasaki (1925, 1926, 1939), Kon'no (1931, 1944), Oishi (1931, 1922), Maejima (1935), Kobatake (1953).

On the whole, the Daidô flora ranges from the lower Jurassic to middle Jurassic, but the plants of the lower horizons in or near the basal conglomerate contain many older elements rather than the pure Jurassic; therefore, some of the lower part of the Daidô System is supposed to go back into the Upper Triassic.

According to the sedimentation basins, there are much differences of facies in sediment and precise correlation between the areas has not yet been completed and especially the question seems to remain on the upper part of the system. Table I is a tentative correlation chart made with the materials available at present.

Taihô System

The Taihô System was named by Kon'no (1928) for the Upper Daidô Formation of Kawasaki and Tamura, because this system is distinctly separated from the Lower and the Middle Daidô Formations. Quite different from the systems mentioned in the foregoing pages, this system is a product of magnificent volcanic activities which overwhelmed Eastern Asia during the Cretaceous time, and is characterized by pyroclastic rocks such as tuff-breccia and tuff-conglomerate with local conglomerate, sandstone and shale. The total thickness reaches nearly 2000 m. Its distribution is confined to the west part of the mapped area, bounded by the Kasekiri fault on the east side. The Taihô effusive rocks build steep mountains of Taeposan (Taihôsan) and Nongaksan (Ryûgakusan) in the west coal field.

The basal conglomerate, more or less 10 m thick, and succeeding reddish shale and lenticular sandstone lie on the Daidô System or the Taishiin Series with clino-unconformity. Pebbles are mostly of quartzite and very rarely of crinoid hornstone. These basal groups have been strongly intruded or interbedded with porphyrite and quartz-porphyrite.

The next group consists of reddish purple tuff-breccia and gradually passes upward to tuff-conglomerate and conglomerate of the uppermost horizon. The lower tuff-breccia has been derived from quartz-porphyrite and porphyrite, while in the upper conglomerates, pebbles of such effusive rocks are rather scant of quantity, but mainly of quartzite, granite, sandstone and limestone. This phenomenon suggests the history of volcanic activity in this area.

The effusive rocks of the Taihô System, such as quartz-porphyrite and porphyrite often show fluidal structure and columnar joints. Reviewing these rocks from the result of the recent studies on the Green Tuff in Japan, we are in wonder whether these effusive rocks were welded tuff rather than lavas.

No fossil has been reported from this system of the Phyongyang Coal Field, but in general the system is lithologically correlated with the Cretaceous Kyongsang Formation of South Korea.

Quaternary System

The old and new river deposits are distributed widely along Taedong-gang and its tributaries.

The old deposits are found as the dissected terrace deposits generally on the limestone area of the Chôsen System, especially along Taedong-gang. The altitude is 60–70 m above sea level and 30–40 m above the river.

The new deposit is mainly of sand, clay and round pebbles of siliceous rocks and is distributed everywhere in the plains about 10 m or less above sea level.

The talus deposit, very frequently found thick in the mountaineous areas is also included in this system.

Eruptive Rocks

As there have been little data studied on the eruptive rocks of this coal field, we cannot give any petrological account and so we only refer to the field observations of the rocks.

Quartz-porphyrites and porphyrites are most important and have been intruded as sheets on a large scale into the lower part of the Taihô System and now remain as the main bodies of Taeposan and Nongaksan. They are greenish grey, white, reddish purple, or green in colour and generally agglomeratic and often have fluidal structure. A porphyrite, usually 2–3 m thick, also occurs as thin sheets in the coal seams of Santo, Kôtô, Taisei, Gentan or Kôbôsan collieries and the coal has been hardened thereby.

Quartz-porphyries and felsites, sometimes difficult to discriminate from each other, occur as intrusive sheets or dykes along the fault between the Taihô System and the Gneiss or Daidô System in Kophyong-myon (Kohei-men) and in Namhyongdyoesan-myon (Nankeiteisan-men). The aplite dyke of Wolpongsan (Geppôzan) in Pusan-myon (Fuzan-men) has maximum width of 500 m.

Beresite, a kind of very quartz-rich aplite and first recognized by Nakamura, is white, fine-grained and porous and appears as dykes with a general width of 20–100 m along the Mukakusan fault or the Kasekiri fault. Nakamura (1936b) noticed hematite in this dyke rock and supposed that the hematite deposite in the limestone near the Angaku fault has been formed by the after genesis of this beresite intrusion.

At the north and the east of Kangtong (Kôtô), diabase sheets are distributed widely in the Kuken and sometimes in the Shidôgû Series. The rock is black, medium or coarse-crystalline, but when weathered greenish black or greenish grey. These green rocks are also found in the Kuken and Shidôgû Series of the area between Syangwon and Samtung (Santo). Many minor olivine-basalt dykes of NNW trend occur in the Samtung district.

With regard to the time of effusion, quartz-porphyry and prophyrite are of course of the Taihô age and the intrusion of the other acid and intermediate dyke rocks might be in the post-Taihô, probably induced by the Taihô disturbance. Basalt dykes may be of Neogene, while sheets of diabase are as old as the Kuken, because they have been participated in the later folding.

Postscript

In the course of preparation of this paper, after the death of the senior author and after the geological map was prepared, Matsushita has got a new opinion concerning the stratigraphy of the Shôgen System. The columnar section (Pl. 1) is made after this new opinion. However, as it is hardly possible to restudy the whole mapped area, the descriptions given on p. 6-8 are not changed. The main difference is in the problem of the Shidôgû —Kuken boundary. The upper part of the Shidôgû is transferred to the Kuken, and the Kuken is now supposed to overlie the Shidôgû disconformably.

Geologic Structure

General

The Phyongyang coal field, though its structure is complicated and difficult to interprete, may be assumed as a synclinorium which was derived from a geosyncline elongated in the east and west direction and being compressed from N and S, and suffered from folding and thrusting.

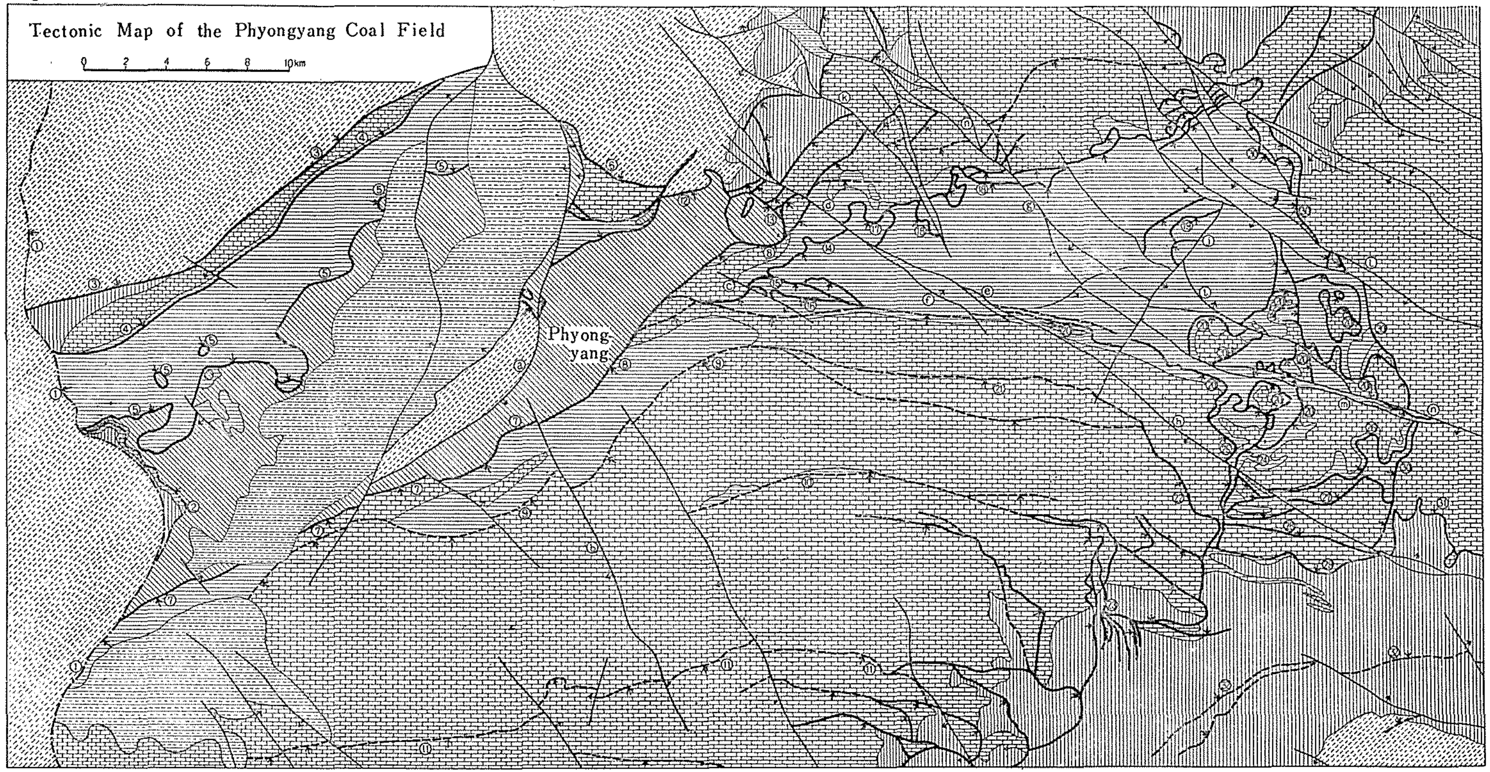
The Heian System, which is the coal-bearing formation of the coal field under consideration, is overlain by the Daidô System with a marked clino-unconformity exposed in the Taihô colliery district and in the Taesyongsan (Taiseizan) district. In the former district the intensely folded Kôten and Jidô Series are covered by the Daidô System with a marked clino-unconformity (Ikebe, 1935), and in the latter the Daidô System rests with a remarkable clino-unconformity on the folded and thrust Kuken, Yôtoku and "Great Limestone Series" (Kon'no, 1931). Accordingly it can be concluded that the Shôgen, Chôsen and Heian Systems were folded and thrust after the Heian period and before the Daidô period, that is probably in the middle Triassic period. This orogenic period belongs to T. Kobayashi's Shôrin phase (Kobayashi, 1930; 1941, p. 442; 1951, p. 211).

The Daidô System together with the older systems was thrust and afterwards eroded and overlain unconformably by the Taihô System. It is evident, therefore, that the thrusting took place after the Daidô period, and before the Taihô period, namely at the end of the Jurassic or in the beginning of the Cretaceous. This disturbance was named the Taihô disturbance by E. Kon'no (1928a).

The complicated synclinorium of the Phyongyang coal field which had been formed in the process stated above was now cut by many normal faults after the Taihô period, presumably during the period from the end of the Cretaceous to the middle of the Tertiary. The trend of these normal faults is WNW in the eastern half of the coal field, while in the western half it is NNW and NNE. It is surely inferred that the Mukakusan thrust was formed also in this stage, since the southern extension of this thrust, i. e. the Angaku or Sainei fault cuts the Taihô System in the Chaelyong-gang (Saineikô) area situated to the south of the coal field under consideration (Shimamura, 1929). Along these normal faults and thrusts were intruded the quartz-porphyry, felsite and beresite which may belong to the Bukko-kuji Series of Tateiwa (1929).

The age of the thrusting in this coal field, as mentioned above, is

Fig. 1



Keirin system & Kokulian granites · Shôgen system · Chôsen system · Heian system · Daidô system · Taihô system · A-type thrust · B-type thrust · Mukakusan thrust · Normal fault

Name of the tectonic lines in Fig. 1

Thrusts
1 Mukakusan
2 Ryûsei
3 Kinsai
4 Chôzan
5 Taihô
6 Sekken
7 Kiyô
8 Chôsuiin
9 Jidô
10 Zen-chûwa
11 Chûwa
12 Butsudôdô
13 Taiseizan
14 Sanshin
15 Chikandô
16 Chôheizan
17 Tomudô
18 Hôwôzan
19 Kokuryûzan
20 Tokusan
21 Bantatsusan
22 Kôreisan
23 Hisekidō
24 Momatsusan
25 Madenpo
26 Jôtôgansan
27 Daitatsuri
28 Shinmadô
29 Kôteisan
30 Suinyû
31 Eisenri
32 Shôgen

Normal faults
a Kasekiri
b Gohô
c Inzan
d Kanshiri
e Momodani
f Kôkyôdô
g Nanzandô
h Yûken
i Saireiri
j Shinbôjyô
k Daisenri
l Hôrairi
m Santo
n Genshinri

dividible into 1) Shôrin phase (post-Heian and pre-Daidô), 2) Taihô phase (post-Daidô and pre-Taihô) and 3) post-Taihô (Matsushita, Kobatake and Ikebe, 1952). It is a noteworthy fact that the thrusting has accompanied folding in 1), while the thrusting did not accompany folding in 2) and 3). The thrusts of 1) and 2) run nearly parallel to the general trend of strata, while that of 3) cuts obliquely the general trend of strata. The thrust of 3), namely the Mukakusan thrust, is a low angle thrust with a dip of 30° or less, while the thrusts of 1) are high angle ones. The thrusts of 2) are of either high or low angle, angle of dip being indefinite. The thrusts belonging to 1) or 2) are sometimes overturned.

We have classified (1952) the thrusting of this coal field into two types: A and B. The A type thrusting took place as a result of overturned folding, whereas the origin of B type thrusting has no relation to folding. In the former the thrusting plane is not gentler than the bedding plane of the strata on both sides, and the strata on the thrusting side are older than those on the opposite side. On the contrary, in the B type thrusting, it is indefinite whether the thrusting plane is steeper than the bedding plane, and whether the strata on the thrusting side is older than those on the opposite side.

In the age of thrusting, A type is older than B. The A type thrusts

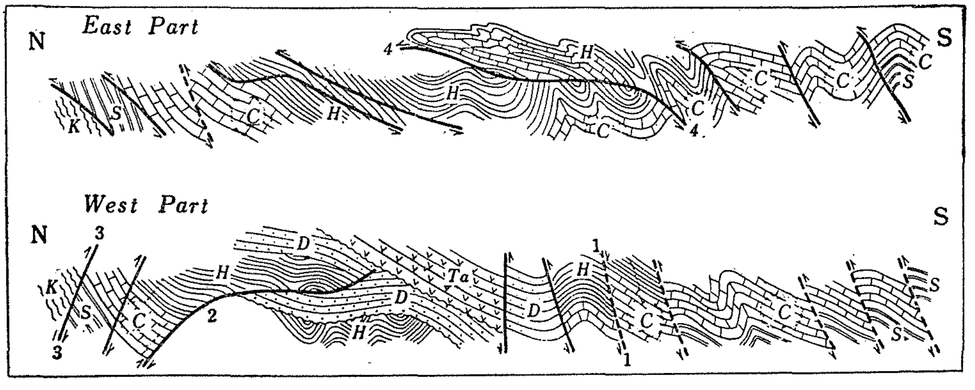


Fig. 2. Schematic geologic profiles.

K : Keirin System or Kokulian Granite
S : Shôgen System
C : Chôsen System
H : Heian System
D : Daidô System
Ta : Taihô System
1 : Jidô thrust
2 : Taihô thrust
3 : Kinsai thrust
4 : Tokusan thrust
– – – – A type thrust
——— B type thrust

are overlain unconformably by the Daidô System, while the B type thrusts except the Mukakusan thrust cut the Daidô and are covered by the Taihô System. It is inferred, therefore, that the A type thrust is post-Heian and Pre-Daidô, i. e. middle Triassic, and that the B type one is post-Daidô and pre-Taihô, i. e. latest Jurassic or earliest Cretaceous. The Mukakusan thrust is probably latest Cretaceous.

On the contrary to the fact that the B type thrusts except the Mukakusan thrust run parallel or subparallel to the general strike of the various formations composing the present coal field, the strike of the Mukakusan thrust, though it belongs to the B type thrust, is NNE or NNW, crossing the general trend of various formations of this coal field. The Mukakusan thrust is a low-angle thrust dipping east-northeast or east-southeast at 30° or less, and by this thrust the Shôgen, Chôsen, Heian and Daidô Systems constituting the Phyongyang Coal Field are overthrust upon the Kokulian Granite. Speaking in detail, the thrust sometimes splits into the Mukakusan thrust proper and the Ryûsei thrust, the latter of which is on the east side. By the former are overthrust the Heian and Daidô upon the Shôgen and Chôsen, which are in turn overridden on the Kokulian Granite. Judging from the general disposition of strata on both sides, such a fault is often interpreted as a normal fault, in which the younger formations on the east side have been downthrown against the older formation on the west side. But as this fault is low-angle, it is to be assumed that the younger formations on the east side have been overthrust upon the older ones on the west. But unless the dip of the thrust is smaller than that of stratra, it is generally impossible that the overthrown side is composed of younger stratra than the components of the downthrown side. It is to be interpreted therefore that before the Mukakusan thrusting a warping in the Korean direction had occurred by the compression from east and west, thus the western marginal district of the Phyongyang Coal Field having been upwarped and the strata of that district dipping east at an angle probably higher than 30°. (See Fig. 6).

For convenience' sake in describing and explaining in detail the geologic structure of the coal field under consideration, the whole mapped area is divided as follows:

1) eastern part,
2) northeastern and central parts,
3) western coal field.

Eastern Part

The stratigraphical units that the eastern part of the mapped area comprises are the Shôgen, the Chôsen and the Heian Systems. Mesozoic formations such as the Daidô and the Taihô Systems are not found in the eastern area.

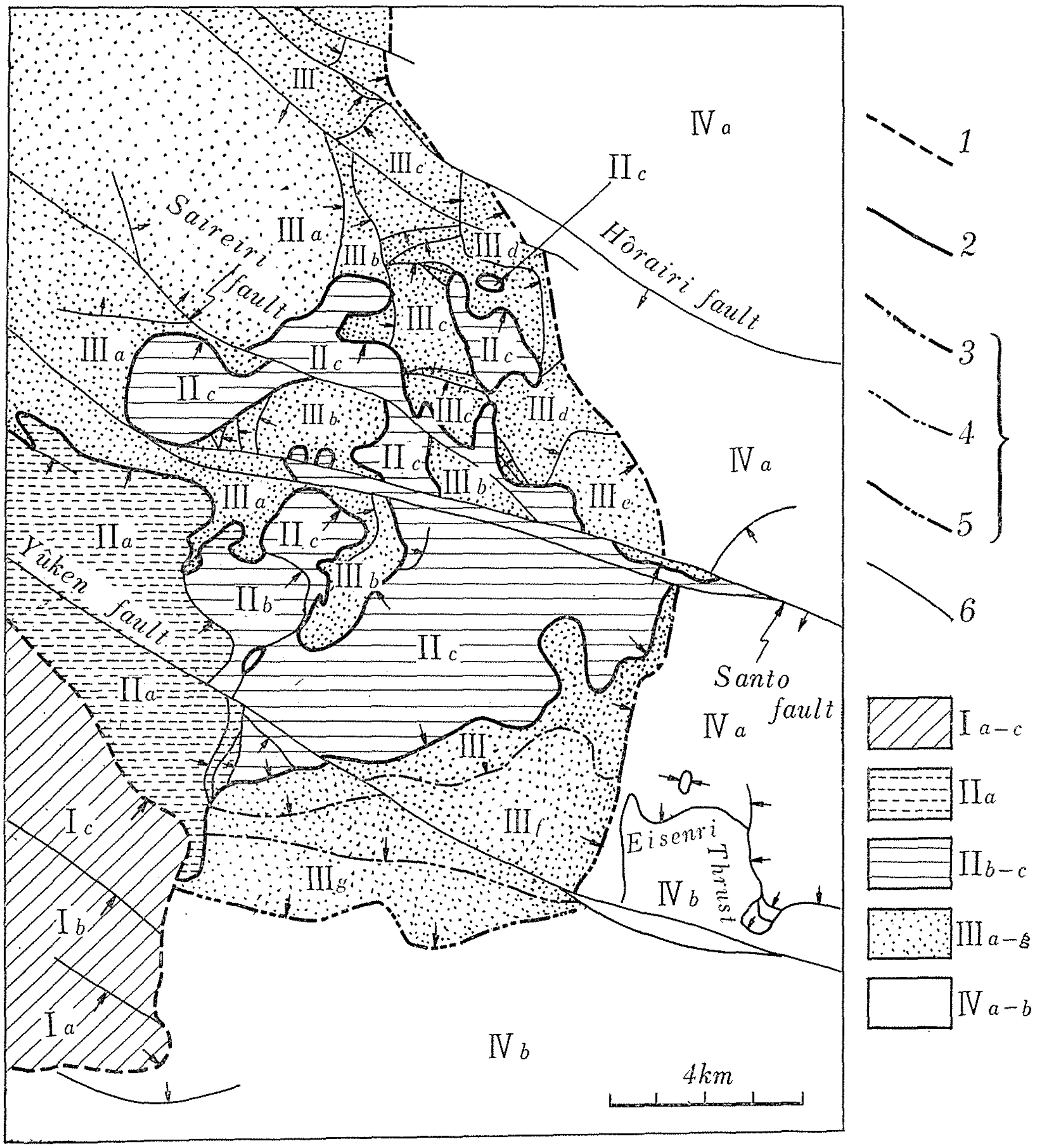


Fig. 3 Tectonic map of the southeastern part (Samtung area) of the Phyongyang Coal Field.

1 Jidô-Kôreisan thrust, 2 Tokusan thrust,
3 Suinyû thrust, 4 Shinmadô thrust,
5 Kôteisan thrust, 6 Other thrusts, subordinate minor thrusts and normal faults.

I_{a-c} Kôreisan Mass, II_a Tokusan Mass
II_{b-c} Tokusan Nappe, III_{a-g} Santo Coal-bearing Mass
IV_{a-b} Outside area.

Such being the case, the age of thrusting which controls the geologic structure of this area is decided only by comparing the structure of this area with that of the central and western parts of the coal field under consideration.

The youngest tectonic elements of the eastern part are several normal faults. These normal faults of WNW-ESE trend are, though morphologically very prominent (straight fault-line valleys, *Kernkol, Kernbat* and fault-troughs) tectonically not so important. These normal faults are supposed to have been born during the Tertiary period, from the fact that many but small dykes of olivine basalt are found subparallel to the fault system.

Most important tectonic elements in this field are four main thrusts, each of which is accompanied by several subordinate thrusts (Fig. 3).

The Suinyû (Mulpi) thrust marks the eastern boundary of the Phyongyang Coal Field. From Kangtong (Kôtô) to Sinchang (Shinsô, about 6 km south of Samtung), this thrust runs in nearly N-S trend, dipping west at 40°-90°. In this area the thrust is traceable exactly with the aid of exposures. For example, near Wonhyoli (Genkôri) the thrust is between the Madenpo dolomitic formation and the Kôjinsan limestone formation with an attitude of N 40°-50°W, 75°-85°SW (Pl. IV fig. 1), and near Syoknumni (Sekirinri) it runs between the limestone of the Kôten Series and the Kôteisan limestone formation with the strike of N 22°W, and the dip of 60° W (Pl. IV, fig. 2), and at Mulpikol (Suinyûdô) the present thrust separates the limestone of the Kôten Series from the Madenpo dolomite with the strike of N 5°W and the dip of 58°W. nI these cases, the Heian System and the Bantatsu Series (the Madenpo formation) were thrust over the Bantatsu and the Kôreisan Series.

At Sinchang (Shinsô) the thrust-line turns west and diverses into three branches [the Daitatsuri (Taetalli), the Shinmadô (Sinmatung) and the Kôteisan (Kotyongsan) thrusts] as shown in the annexed tectonic map (Fig. 3). Finally, these three southward thrusts are overlapped by the Tokusan (Toksan) and the Kôreisan (Kolyongsan) thrusts (=Jidô thrust) at Tamokli (Tamokuri). The thrust planes of these three branches are somewhat low-angle, compared with that of the type Suinyû. The Kôteisan thrust runs between the Kôreisan—Yôtoku Series and the Yôtoku—Kuken—Shidogû Series.

At the south of Kangtong the Suinyû thrust turns west, and diverses into several branches, all directed to the north, opposite to the above mentioned southern three ones. This group of the northward thrusts runs westward along Taedonggang until it joins with the eastern extention of the Kiyô thrust in the Kôbôsan district of the central coal field.

The Tokusan thrust is a low-angle thrust of B type, by which the

Chôsen System together with the lower part of the Kôten Series was thrust over the Heian System. The mass sandwiched between the Tokusan (above) and the Suinyû (below) is named as the Santo Coal-bearing Mass, because it consists chiefly of the Heian System in synclinorium-like structure with abundant coal pockets. The horizontal and vertical distribution of the Tokusan thrust is more complicated than that of the Suinyû. Near the Taisei colliery in the central coal field, the thrust runs nearly straight from W to E directed to the north (A type). Then turning to the south near Tokyo (Dokyô) the thrust runs in nearly N-S trend to Tamokli. From this turning point a tongue-shaped projection of the thrust sheet toward east covers the Santo Coal-bearing Mass in wide area (Fig. 3). The northeastern end of this tongue nearly touches the Suinyû thrust (the eastern margin of the coal field).

The thrust plane under this tongue is so wavy, that many *Klippe*, *Halbklippe* and *Fenster* are recognized as shown in Fig. 3. This tongue is composed of the overturned isoclinally folded strata, which is cut by the undulating thrust Plane (Pl. V). This is one of the most typical B type thrusts. This tongue might have slided far to the northeast after the original thrust and foldings were constructed. The name Tokusan Nappe may be suitable for this slided tongue (Fig. 3; Pl. V). The sliding on such a large scale might have brought about many subordinate high-angle thrusts in the sliding Tokusan Nappe and in the underlying sandwiched coal-bearing mass, similar to the well-known Highland structure of Scotland (see the Profile No. I in the geological map). As coal-seams are incompetent for folding, coal in the Upper Jidô Series might have been shifted and accumulated in these minor thrust planes, thus the workable coal pockets were originated. It should be mentioned that the workable coal pockets in the Samtung area are almost always found very near the Tokusan thrust. Examples of the minor structures concerning the Tokusan thrust may be seen in the annexed photographs. (Pl. VI—Pl. XI).

The Kôreisan (Kolyongsan) thrust is a high-angle thrust which runs through the area of the Chôsen and the Shôgen Systems. Nakamura has convinced that this is the eastern prolongation of the Jidô thrust in the central coal field, which is the very thrust discovered by him for the first time in the Phyongyang Coal Field. The trend of the Jidô thrust is NE in the type area, and E-W in the district between Sadong (Jidô) and the present area, and it changes to N-S at the northwestern foot of Mt. Kolyongsan (Kôreisan) which is encircled by the Kôreizan thrust at its northern foot (Pl. XII fig. 1). Then the thrust overlaps the Tokusan and the Suinyû thrusts, while it is in turn overlapped by the Pisyokkol thrusts.

The Pisyokkol thrusts form a group of thrusts in the district composed of the Chôsen and the Shôgen Systems. The thrust runs sub-parallel to the Jidô thrust in the district intervening between Phyongyang and

Tyunghoa, but approaching Pisyokkol it changes its direction suddenly to N-S and at the same time it branches many subordinate thrusts as shown in the geological map.

The eastern outside area of the coal field is made up of the Chôsen and the Shôgen Systems. The Shôgen System in the Syangwon—Pemi district (the southeast corner of the mapped area) are isoclinally folded, dipping north at about 40°. This district is bounded on the north side by the Eisenri (Yongchyonli) thrust, by which the Chôsen System (younger) was thrust from the north over the southern Shôgen System (older). At Yongchyonli the thrust plane is just below the Monsanri quartzite, the basal member of the Cambrian (Pl. XIII, fig. 1, 2).

The Cambro-Ordovician Chôsen System east of Samtung shows a synclinorium with the axis of E-W trend pitching west (PI. II fig. 1, 2). The axis of the synclinorium runs along Namkang.

Generally speaking, the eastern coal field structurally consists of four thrust masses overthrust successively north-northeastward (Fig. 4). The lowest mass is the Santo Coal-bearing Mass, encircled by the Suinyû thrust, thrust over the pre-Heian formations in the outside area of the coal field. Thus the Santo Coal-bearing Mass is a compressed and shifted synclinorium made up of the Heian System.

The second is the Tokusan Mass with its projected tongue Tokusan Nappe, bounded by the Tokusan thrust, chiefly consists of the Ordovician and the lower part of the Kôten Series.

The third is the Cambro-Ordovician Koreisan Mass, bounded by the Jidô-Kôreisan thrust.

The fourth or the uppermost mass is the Chûwa (Tyunghoa) Mass, made up of the Shôgen and the Chôsen Systems.

The line connecting the main turning points of these thrusts shows NNE direction as shown by a thick arrow in Fig. 4.

During the tectogenese, strata of different lithofacies seem to have been moved in different ways. The Carboniferous Kôten Series, rich in limestone, stratigraphically the lowest member of the Heian System, unconformably overlie the Ordovician Bantatsu Series of the Chôsen System is, from the tectonical point of view, apparently more akin to the Bantatsu (limestone) Series. This fact is clearly proved by tracing the characteristic reddish purple Alnemi shale, the basal claystone of the Kôten (Pl. VI fig. 1; Pl. VII fig. 1; Pl. IX fig. 2; Pl. XI fig. 1).

Northeastern and Central Parts

At a glance of the geological map of this area we may easily find that one syncline and one synclinorium play an important rôle in the distribution of tectonic lines. The former starting from Taesongsan (Taiseisan), goes southwest to the northern suburb of Phyongyang City, then changes the direction towards SSW, passes through the City and disappears

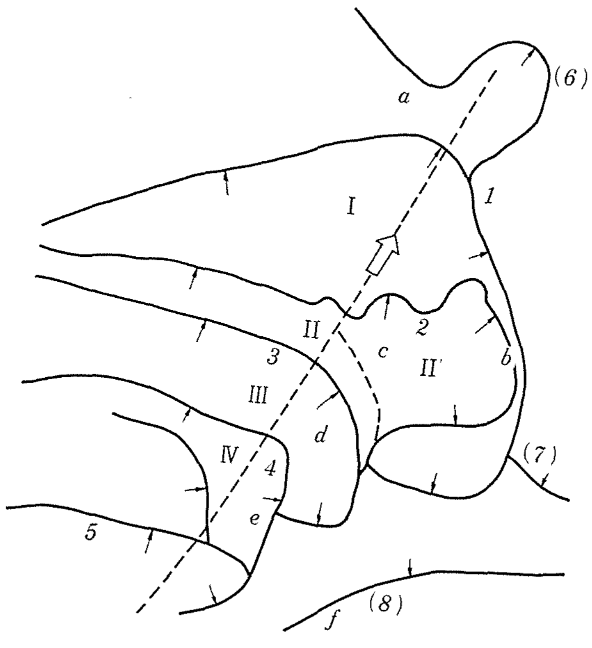


Fig. 4. Schematic tectonic map of the eastern part of the Phyongyang Coal Field.

1. Suinyû thrust
2. Tokusan thrust
3. Jidô-Kôreisan thrust
4. Pisyokkol thrust
5. Chûwa thrust

(6). Mulasi thrust
(7). Eisenri thrust
(8). Shôgen thrust

} Outside area of the Coal Field

I. Santo coal-bearing mass
II. Tokusan mass
II'. Tokusan nappe
III. Kôreisan mass
IV. Chûwa mass

a. Kangtong (Kôtô)
b. Samtung (Santo)
c. Toksan (Tokusan)
d. Kolyongsan (Koreisan)
e. Pisyokkol (Hisekidô)
f. Syangwon (Shôgen)

under an alluvial plain. This syncline is younger than the synclinorium and simple in structure. The synclinorium, appearing at Tyawelyongsan (Saireisan), runs westwards through the north part of the Taisei colliery district, reaches the Kobangsan (Kôbôsan) district and then abuts on the syncline. Separated by these synclinal basins, general structures of the area on south side are much different from those on the north and moreover, these areas are divided into minor subareas by the NW-SE faults. Structures of each subarea are variable, according to its formations. A brief description of the subareas is given below.

Area situated south of Taedonggang (Daidôkô) and west of Namkang (Nankô) and Syangwonchyon (Shôgensen).

The area between Taedonggang and Tyunghoa (Chûwa) is mainly composed of the Chôsen System accompanied by the Heian System occurring in narrow zones. Of the former system the Chûwa Series is developed in the vicinity of Tyunghoa (Chûwa) and in the southeastern part of the area. The remainder of the area is occupied by the Great Limestone Series, forming a peneplian where the outcrop of rocks is scanty and minute structures are untraceable.

One of the geological features worthy of special mention in this area is the Jidô overthrust. This memorial thrust was first reported by Nakamura in 1918 and his detailed description was the clue to elucidate the complicated structure of the Phyongyang Coal Field. This thrust can be traced southwestwards from Sadong (Jidô) for more than 15 km. The Chûwa Series, on the southeast side of the thrust striking NE-SW, dipping 40°-45°SE and having overturned anticline, has been overthrust upon the Heian System (mainly the Upper Jidô Series) of the same structure. The dip of the thrust plane fluctuates from 45° to 80° SE. It changes the direction to the east at the east of Sadong and is supposed to run through the limestone area towards Sungholi (Shôkori), giving off subthrusts.

Beside the Jidô thrust there are two prominent thrusts in this area, running parallel to the Jidô. Of the two the north one, passing south of Yusinli (Ryûshinri), is that by which the Great Limestone Series has been overthrust upon the same series and in part on the Kôten Series with bedding plane steeper than the thrust plane. By the south one which passes the north slope of the hills just north of Tyunghoa, the Chûwa Series has been overridden upon the Great Limestone Series. As the two above-mentioned thrusts run east, they curve southward, branching off subthrusts which took part in the formation of the imbricated structure of Pisyokkol (Hisekidô).

The faults in this area strike NNW-SSE continuously for considerably long distance, but when generally viewed, the relation between faults and thrusts seems rather simple.

Phyongyang (Heijô)-Kampuk (Kampoku) area.

This area occupies the Heijô synclinal basin and its adjacent north.

The Daidô System of the Phyongyang City, the south side of which is demarcated by the Kiyô thrust, forms a typical syncline with its axis paralled to Taedonggang and plunges southward. The inclination of the synclinal limbs is measured at about 20°. The north wing has been overthrust from the north by the Heian System along the ridges of Kampuksan (Kampokusan) and Amisan (Gabisan).

The triangular district north of Kampuk is bordered by the Kasekiri fault (Nakamura 1936) on the west and by the Suiken thrust (ibid) on the east and has a special structure. There we find at least four overthrusts overlapping each other. Stating briefly from the south, by the first thrust the Heian System together with the basal part of the Daidô System has been overthrust on the Daidô System; by the second thrust the Kôten Series on the Kôten and the Jidô Series; by the third the Kuken Series on the first and the second thrusts; by the fourth the Chôsen and the Heian Systems on the third thrust, the former two thrusts have been caused by the force from NW and the latter two from N. The Suiken thrust is the boundary between the Gneiss System and the Chôsen System, the overthrusting force being directed from NE to SW. Thus in this narrow area forces of three different directions meet together and several formations were crumpled.

Area south of Taedonggang, northwest of Kolyongsan (Koreisan) and east of Syangwon-chyon (Shôgensen).

The Taishiin synclinorium mainly composed of the Heian System occupies the northern half of the area, while the Chôsen System is widely developed in the southern half.

In Putong-myon (Fûdô-men) and Mantal-myon (Bantatsu-men), the south side of the synclinorium, the structure is rather simple, and the members of the Chôsen System are distributed from south to north in ascending regular order, only repeating rather gentle foldings, interrupted by two thrusts. By the Kôreisan thrust (Ikebe 1939, Kobatake 1952) the Kôreisan Series has been overridden on the Bantatsu Series and the thrust, then changing its NNW direction to E-W and dipping 30°S, reaches the south of Sungholi (Shôkori). The Bantatsusan thrust (Kobayashi 1930), branched from the above-mentioned thrust, passes the north slope of Mt. Mantalsan (Bantatsusan), dipping at about 60°S, then joins again with the Kôreisan thrust and continues to the Jidô thrust.

The structure in the synclinorium is inferred mainly from the distribution of the Heian System. This synclinorium, composed of several folds with axes running in E-W direction, is broken into several blocks by NW-SE faults, and the district increases its structural complexity gradually eastward probably under the influence of the complicated structure of the Samtung (Santo) district. The Tokusan thrust (Ikebe 1939) is represented by the bounbary between the Kôten and the Lower Jidô Series, but the strikes and the dips (30°-60°N) of both series are so close that we can hardly point out the existence of this thrust in the field and in many cases the thrust plane is overturned, so that it is seemingly in normal sequence, the Kôten Series comes beneath the Lower Jidô, therefore, we may look this upon an underthrust. This thrust is accompanied by several minor subthrusts in the Taisei district and continues into the Kobangsan area.

In the district of the Kôtô colliery, the Jidô Series has been pushed upon the Kôten Series by a thrust dipping S at 50° and the latter series in turn on the Great Limestone Series. The adjacent part, south of Kangtong, (Kôtô) where five parallel thrusts are cut by several NW faults, exhibits a splendid imbricate structure of the Kôten and the Ordovician limestone.

Around the Fuknongsan (Kokuryûsan) mass, Wontan-myon (Gentan-men), sandstone belts of the Kôbôsan Series, repeating intense folding and making craggy ridges, appear and disappear under the influence of several thrusts and at the compressed core of the fold, coal-bearing Upper Jidô Series has been squeezed out. The mutual relation of the structures of this Fuknongsan thrust group (Kobatake 1953), however, has not yet been fully explained.

The major faults in NW-SE or NNE-SSW direction cut the Taishiin synclinorium. The Momodani fault (Kobatake 1953) starting from Samsandong (Sanzandô), passes near the Momodani pit of the Taisei coal mine and reaches Mantalhyong (Bantatsuken), splitting into two, and probably continues to the Yûken fault (Ikebe 1939). The northwest end of this fault is supposed to be related to the Kanshiri fault (Matsushita 1933). The Nanzandô fault (Kobatake 1953) appears at Syonwoli (Shôuri), give off subfault at Namsandong (Nanzandô) and affects the distribution of the Kôbôsan and Taishiin Series, especially the uppermost Yôdô bed of the latter. The Saireizan fault (Kobatake 1953) runs along the west foot of Tyawelyongsan (Saireizan), leaving the Taishiin Series on the mountain, curves to NW at Tongsoni (Tôzairi), shifting the exposure of the Jidô Series and at Henhyondong (Kôkendô) crosses Taedonggang. These faults have the downthrow on SE side.

Contrary to these NW faults, the Shinbôjô fault (Kobatake 1953), starting from Hoachonli (Kasenri), runs toward NNE along the valley and may reach the eruptive mass at Myonglyaweli (Meireiri).

In this area the Taishin Series remains unaffected by the thrust movement and the folds in it are considerably regular and simple, while in the Jidô and the Kôbôsan Series,not only thrustings but also foldings are very intense and irregular.

Area north of Taedonggang.

The synclinorium of Kobangsan district is the west extremity of the Taishiin synclinorium, but there are remarkable differences between these synclinoria. The type of the Taishiin synclinorium is normally symmetrical, while that of the Kôbôsan is overturned toward north, and so the general dip of the district is to the south.

The Kôbôsan Series composes the central part of the wedge-shaped hilly mass. On the south side of the hills several thrusts, large or small in scale, run close to each other and one of them defines the boundary between Kôbôsan and the Upper Jidô Series, and by another the Lower Jidô Series is overthrust on the Upper Jidô (Chôheisan thrust, Kobatake 1953). Both the Kôbôsan and the Jidô Series have been subjected to intense folding and shattering and one of the vivid examples can be seen on a cliff on the right bank of Taedonggang near Nongtang (Ryûtô). There, two or three belts of the Upper Jidô sandstones have been folded and crumpled again and again, resulting in the wide exposures of the sandstones on the hills of the right-bank and by these forces the above mentioned thrusts and faults were induced. The Chôheisan thrust may be the continuation of the Kiyô thrust from the west and the Tokusan thrust from the east.

On the north side of the hills and in the low land along the Kangtong highway, the distribution of the strata is generally normal, ranging from the Bantatsu Series up to the Kôbôsan. On the north slope of the hills there runs, in the Kôbôsan Series, the Sanshin thrust and at the foot of the Taesyongsan (Daiseizan) massif the Chôsuiin thrust, a branch of the Kiyô thrust, locates the boundary between the Daidô System and the Heian or the Chôsen System, and in the plain the Ordovician limestone expose itself making an anticline.

In the basement formations of the Daidô System at the Taesyongsan the thrusts occurred in the Pre-Daidô age in the following order from south to north: the Yôtoku and the Kôreisan; the Kuken, the Yôtoku and the Kôreisan; the Yôtoku and the Kôreisan; the Kuken; the Chokken Series; (the former group thrust up to the next), and all the thrust planes dip SE. These thrusts are cut by the Kanshiri fault and the south boundary is the Chôsuiin thrust.

On these dislocated formations rests the basal conglomerate of the Daidô System. The general dip of the system is about 20°SW and there is no folding worth mentioning. Judging, however, from the distribution and the brecciation of the basal conglomerate, and the arrangement of the Kaiundô alternation and the *Corbicula* Zone, it seems natural to consider that the basal part of the Daidô System slipped along the unconformity plane from SW to NE and the Kaiundô alternation slided up slightly over the lower part of the system (Daiseizan and Butsudôdô thrusts, Kobatake 1953), thus exposuring windows of the Kuken Series in the valley.

Area east of the Kanshiri fault and north of Taedonggang.

In this area there are some structural differences between the mountainous part and low hilly part near the river. The former is composed of the older formations than the Heian System and the latter mainly of the Heian and the Chôsen Systems.

The structure of the area between the Kangtong highway and the Taedonggang is governed by two prominent groups of thrusts, the one rules the Heian System and the other the Chôsen System.

In the Heian System there are two main thrusts, and the older one appears near Tumukol (Tomudô) and runs eastward, bending irregularly, being cut by faults and reaches Ponghoansan (Hôwôzan). By this thrust the Jidô Series, the Lower and the Upper, has been overthrust mainly on the Kôten or the Bantatsu Series, and on this thrust mass, the Kôbôsan Series slided up from the south, to dispose the Kôbôsan Series on the Jidô or the Kôten or even on the Kôbôsan Series itself. This second thrust is supposed to be the east continuation of the Sanshin thrust and named the Hôwôsan thrust.

On the contrary, in the Chôsen System two or three thrusts from SE to NE are remarkable and they appear rather straight, separating the Great Limestone Series from the Yôtoku Series.

The area north of the highway above-cited is, so to say, the combination of thrust and faults. The Granitegneiss, Shôgen and Chôsen Systems are the important members. Their general strike is NE-SW, the dip southward and the strata seemingly monoclinal but the complicated repetition of folding is of course doubtless. The thrusts from SE or S has overridden the younger formation over the older. Around the Chyongunsan (Seiunsan), Sityok-myon (Shisoku-men) for instance, the Chokken, Shidôgû, Kuken, Yôtoku and the Greet Limestone Series are separated from one another by the thrusts with southward dip. This sort of thrusts counts at least four in the area and the southmost one is the Chôsuiin overthrust. These are displaced by many NW-SE faults of various magnitude. The Kanshiri fault is supposed in the valley of Syongsanni (Seizanri) immediately north of the Taesyonsan. The Taisenri fault (Matsushita 1933) runs NW and at Talpakkol (Getsumeidô) splits into two, one of which takes the course of NNW and reaches the quartz porphyry mass of Masanni (Masanri) and the other of NW trend goes to Bangyongdong (Banryûdô). This fault is expected to cross Taedonggang, but in the Taisei district this fault seems to have nothing to do wi th the structure of the Taishiin Series.

In the northeast corner of the mapped area, near Kangtong, are distributed all members of the Chôsen System, and the structure of the area is markedly divided into two patterns by the Suinyû thrust. Of the faults which have produced the mozaic structure in the terraine immediately south of Kangtong, two prominent ones run northwest crossing Sutyongtyon (Suishôsen) and the north one separates the Great

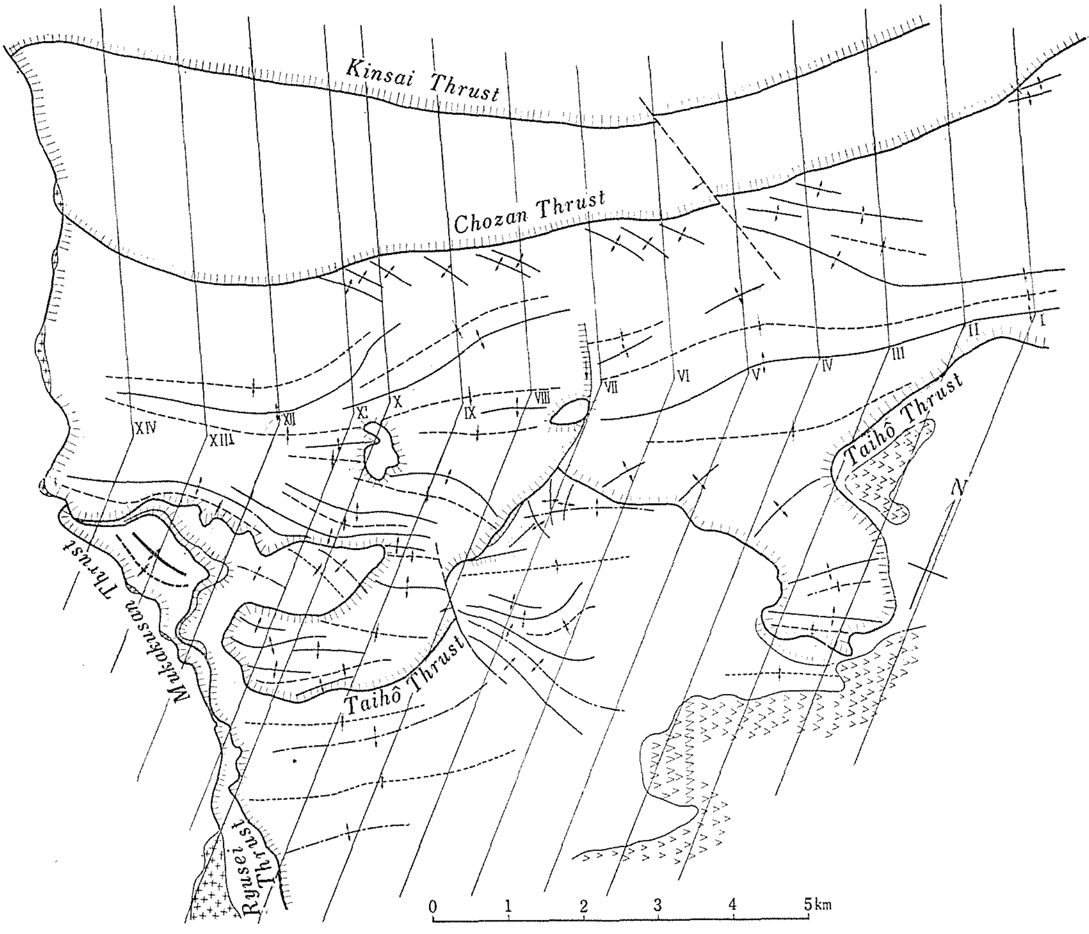


Fig. 5. Tectonic map of the northwestern part of the Western Phyongyang Coal Field.

Paralell lines with numbers I—XIV show locations of profiles (Pl. XIV)

Main thrust

Secondary thrust

Normal fault

Axis of folding

in the Shôgen ~ Chôsen System

in the Heian System

in the Daidô System

Beresite

Taihô System

Limestone Series from the Shôgen System. The Yôtoku and the Kôreisan Series have been overthrust from SE upon the Shidôgû and the Kuken Series. The latter two series in turn have been overthrust from NW by the Suinyû thrust on the Shidôgu limestone. The overthrust of NW direction cited above is a thrust with angle of 30° or less. In the area beyond the Suinyû thrust, the leading structure is parallel faults, more than eight, running NW and dipping SW, but most of them terminate at the Suinyû thrust. One of the noteworthy features of the area is the intrusion of the diabasic sheets. The majority of them appear in the Shôgen System, especially crowded in the neighbourhood of Kangtong and Syungtokli (Sutokuri).

Summarizing roughly the main structure of the east half of the mapped area, the following inference seems possible.

There are two synclines and one anticline in the E-W direction, namely, the north syncline lies in the Gentan district and the south one coincides with the Taishiin synclinorium, an anticline intervening between them, and all these folds converge in the Kôbôsan district.

The anticlinal part and the lower part of the south wings of the synclines were especially crushed or disturbed, and to the Kôbôsan district, the terminal thin part of this fold, various lateral pressures were concentrated and the synclinal axes overturned to north and the strata were greatly destroyed.

Moreover, comparing the degree and complexity of folding as seen in the Taishiin Series, with those of the lower series of the Heian System, we may recognize that the deep-seated lower members have been subjected to much more disturbance than the upper-seated series.

Western Coal Field

Major thrusts and faults together with axis of folding in the western coal field are shown in Fig. 5.

As previously mentioned, the western border of the coal field is well defined by the Mukakusan thrust of nearly NS trend, which is one of the most important tectonic line in West Korea. Its southern prolongation is the Angaku thrust in western Hwanghae-do (Kôkai-dô). Its northern trace is not so clear, as it runs through the gneissose rocks of the Keirin System.*

The Mukakusan thrust in the present field runs between the Mukakusan granite-gneiss on one side and the Shôgen, the Chôsen, the Heian and the Daidô Systems on the other, dipping eastward at about 30° (Pl. XV). The hanging wall is occupied by these younger formations. At first

* Recently E. Takahashi (1952) has mentioned that the northern extention might be traced between gneiss (west) and the Shôgen System (east) in the coastal region of North Pyongam-do (Heianhoku-do).

Nakamura had thought (Nakamura, 1936) that this is a low-angle normal fault, but later he has changed (Nakamura, 1938) his opinion that this might be a thrust fault. We have explained (Matsushita, Kobatake & Ikebe, 1952) the mechanism by which this peculiar thrust was born as schematically shown in Fig. 6. However, it is one of the important problems not yet solved whether this is a thrust or a normal fault.

The Ryûsei thrust (Pl. XIX fig. 2) runs subparallel to the Mukakusan between the Chôsen System and the Heian-Daidô Systems, and has the similar character as the Mukakusan. Although this may be possible to be a low-angle normal fault, we have an opinion that the Ryûsei is a subordinate one to the main Mukakusan thrust (Pl. XV). If these are thrusts, as we suppose, the Mukakusan (the Ryûsei inclusive) is a youngest major thrust in Korea, active after the Taihô period, since the Taihô System is cut by the above-mentioned thrust in the southwestern corner of the mapped area. It is a peculiar fact that the thrust plane of the Mukakusan is intruded by beresite sheets at several places (Fig. 5).

The northern limit of the western part of the coal field is marked by the Kinsai thrust of ENE trend, running between the Shôgen-Chôsen Systems and the paragneiss of the Keirin System. As the area where

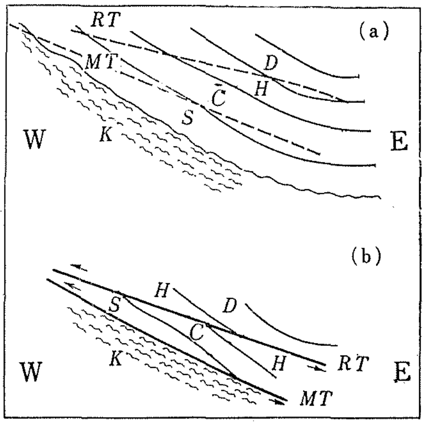


Fig. 6. Schematic profile showing the mechanism of development of the Mukakusan thrust.

a) Before thrusting b) After thrusting

K : Kokulian (Mukakusan) Granite
S : Shôgen System
C : Chôsen System
H : Heian System
D : Daidô System
MT : Mukakusan thrust
RT : Ryûsei thrust

the thrust runs is topographically very flat (the Syunhoakang (Junwakô) Peneplain), and exposures in that area are very poor, it is difficult to trace the thrust-line exactly or to observe the dip of the thrust-plane (Pl. XVI; Pl. XVII fig. 2). Nakamura has wondered (1938) whether the thrust dips south or north. Finally, he has supposed that the thrust dips north at high angle, from the fact that the boundary between the paragneiss and the Shôgen-Chôsen Systems is straightly traced. The eastern prolongation of the Kinsai thrust is seen at Imwon-myon in the central part of the coal field, where the gneissose rocks are thrust over the Daidô System. This fact suggests that the thrust was active after the Daidô, and in all probability before the Taihô.

The Chôzan thrust runs subparallel to the Kinsai, between the lower part of the Kôten Series and the Lower or Upper Jidô Series, along the northern foot of the Tyangsan (Chôzan) hill range. This is a supposed thrust suggested from the distribution of the Ordovician Great Limestone, the Kôten and the Jidô Series, in the following manner:

(1) the Kôten Series is abnormally thin;

(2) the basal Kôten Alnemi shale can be traced very near the Lower or Upper Jidô Series.

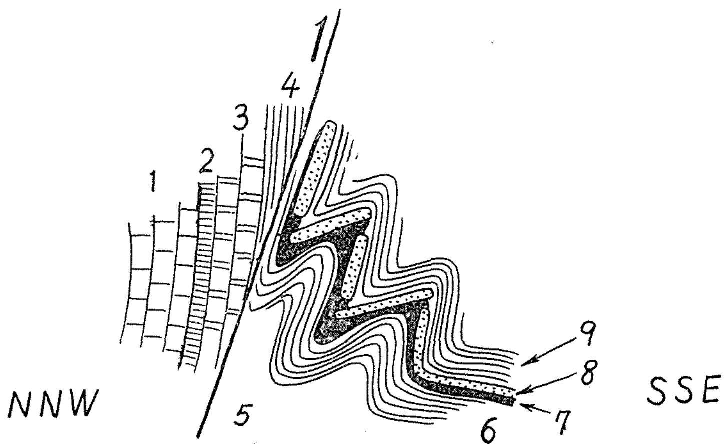


Fig. 7. Schematic profile of the Chôzan thrust

1. "The Great Limestone" Series
2. Alnemi shale } Kôten Series
3. Limestone } Kôten Series
4. Shale } Kôten Series
5. Lower Jidô Series
6. Shale and sandstones } Upper Jidô Series
7. Coal } Upper Jidô Series
8. Chôzan quartz sandstones } Kôbôsan Series
9. Yellow shale } Kôbôsan Series

In the early stage of our research, the presence of the Chôzan thrust was not yet recognized, i.e., the Ordovician, the Kôten and the Lower Jidô were thought to be successively superposed. After the profiles were made, the Chôzan hill range was restudied, resulting in the discovery of the tectonic line. This is the reason why the Chôzan thrust is not shown in the annexed profiles (Pl. XIV) which had been prepared before the restudy above-mentioned.

The severe lateral force from the north resulted in the birth of many oblique folds of the compressed strata (the Jidô and the Kôbôsan) (Fig. 5). The Chôzan sandstones of the basal Kôbôsan show distribution *en echelon* as seen in the photograph (Pl. XVI; Pl. XVII fig. 1). Sometimes the hard quartz-sandstone beds have been broken into several blocks as seen in Fig. 7.

The Taihô thrust, first discovered and named by E. Kon'no (1928) is the most important tectonic line in the western coal field (Pl. XVIII; Pl. XIX fig. 2; Pl. XX; Pl. XXI; Pl. XXII). This is a low angle thrust, the plane of which is very wavy as seen in the profiles (Pl. XIV). A synclinorium consisting of the Heian System has been displaced southward as a Nappe (Chôzan Nappe) on the Daidô System which is in turn unconformably underlain by the Heian System in situ. This is a typical B type thrust. The Taihô thrust is overlain by the basal conglomerate of the Taihô System at the southwest of Mt. Sunlyangsan (Shôreizan), so that the age of the thrust is infered to be post-Daidô and pre-Taihô.

The Daidô System covers the strongly folded Heian System unconformably at Okkapong (Gyokkahô) (Profile No. VI and VII in Pl. XIV). This fact shows that the main period of folding of the Heian System is pre-Daidô.

The Kiyô thrust is the southeastern limit of the western coal field. Opposite to the Taihô, the Chôzan and the Kinsai thrusts, the Kiyô is an overthrust caused by the pressure from the south, similar to many thrusts in the central and eastern parts of the coal field.

Literature

FELIX, J. (1887) : Untersuchungen über fossile Hölzer. Zeitschr. d. Deut. Geol. Gesl., Bd. 39, S. 517–519.

FUKUCHI, N. and I. SUGIMOTO (1905) : Report of the Survey of Coal at Santo (Samtung), S. Pyongam-do and Shariin (Saliwon), Hwanghae-do (In Japanese). Imperial Japanese Army.

GOTHAN, W. (1910) : Die fossilen Holzreste von Spitzbergen. Kongl. Svenska Vetenskapsakademiens Handlingar, Bd. 45, No. 8, S. 23.

GOTTSCHE, C. (1886) : Geologische Skizze von Korea. Sitz, d. Königl.-preuss. Akademie d. Wiss. z. Berlin, Bd. 2, S. 869.

GOTTSCHE, C. (1889) : Ueber den Mineralreichtum von Korea. Mitt. d. Geogr. Gesellsch. z. Jena, Bd. 8, S. 4.

HATAE, N. (1935) : Lower Part of the Heian System (In Japanese). Jour. Min. Soc. Korea. No. 149–150.

HATAE, N. (1936) : Report of the Survey on the Feldspar Resources in the Taedong and Kangso Counties, South Pyongam-do (In Japan.). Bull. Mineral Survey Korea. Vol. 11, No. 1.

HATAE, N. (1938) : On the Subdivision of the Kôten and Jidô Series (In Japan.) Jour. Geol. Soc. Japan, Vol. 45, pp. 486–487.

HATAE, N. (1939) : Stratigraphic Division of Heian System on Fossil Foraminifera (In Japan.). Jubilee Publication in the Commem. Prof. H. Yabe's Sixtieth Birthday, Vol. I.

HUZIMOTO, H. (1938) : Some Foraminiferous Fossils from the Kôten Series of Zidô Coal-Field, Tyôsen. Jour. Geol. Soc. Tôkyo, Vol. 45.

IKEBE, N. (1935) : Geologic Structure of the Western Margin of the Phyongyang Coal Field (In Japan.). Jour. Geol. Soc. Japan, Vol. 42, pp. 319–320.

IKEBE, N. (1937) : Thrust Structure of the Santo District, Phyongyang Coal Field (In Japan.). Jour. Geol. Soc. Japan, Vol. 44, pp. 614–5.

IKEBE, N. (1939) : Geologic Structure of the Santo and Shôgen Districts to the East of Phyongyang (In Japan.). Jour. Geol. Soc. Japan, Vol. 46, pp. 433–444.

IKI, T. (1906) : General Geology in the Vicinity of Phyongyang, Korea (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 13.

IKI, T. and S. SUZUKI (1906) : Report of the Survey on the Mining Industry.

INOUYE, K. (1907) : Geology and Mineral Resources of Korea (In Japan.). Bull. Imp. Geol. Sur. Japan. Vol. 20, No. 1.

INOUYE, K. (1913) : The Coal Resources of Korea in "The Coal Resources of the World." Ing. XII, Internat. Geol. Congress, Vol. 1.

INOUYE, K. (1914) : Coal in Korea (In Japan.). Jour. Geogr. Tôkyo, Vol. 26, Jour. Mining of Japan. Vol. 29, Report Imper. Geol. Survey Japan, No. 43.

INOUYE, K. (1924): Coal Resources of Japan (In Japan.). Jour. Geogr., Vol. 36.

ISHIKAWA, T. (1930): Preliminary Survey on the Alumina Ore in Korea (In Japan.). Report of Dressing and Smelting Experiments. VII.

KAWASAKI, S. and E. TAMURA (1912): Coal in Korea (In Japan.). Bull. Mineral Survey Korea, I-1.

KAWASAKI, S. (1925): Older Mesozoic Plants in Korea. Bull. Geol. Survey Korea, IV-1.

KAWASAKI, S. (1925): Coal of Korea (In Japan.). Jour. Fuel Assoc. No. 32.

KAWASAKI, S. (1926): Geology and Mineral Resources of Korea. in "The Geology and Mineral Resources of the Japanese Empire."

KAWASAKI, S. (1927): Flora of the Heian System in Korea I. Bull. Geol. Survey Korea, VI-1.

KAWASAKI, S. (1931): Flora of the Heian System in Korea II (Atlas). Bull. Geol. Survey Korea, VI-2.

KAWASAKI, S. and E. KON'NO (1932): Flora of the Heian System in Korea III. Bull. Geol. Survey. Korea, VI.

KAWASAKI, S. (1934): Flora of the Heian System in Korea II (Text) Bull. Geol. Survey. Korea, VI.

KAWASAKI, S. (1940-41): Geological Age of the Heian System of Korea. Jubilee Publication in the Commemoration of Professor H. Yabe, M.I.A. Sixtieth Birth Birthday, Vol. II.

KIKKAWA, I. (1925): Studies on the Phyongyang Anthracite (In Japan.). Mem. Fac. Sci. Eng. Waseda Univ. 2.

KIKKAWA, I. (1926): Anthracite of Korea (In Japan.). Jour. Min. Assoc. Japan, Vol. 42.

KIKKAWA, I. (1927): On the Metamorphism of Coals of Korea (In Japan.). Coal News. Vol. 2.

KOBATAKE, N. (1935): On the Heian System on the North Side of the Taedong River, East of Phyongyang (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 42.

KOBATAKE, N. (1937): On the Geology of the Taisei Colliery and its Vicinity (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 44.

KOBATAKE, N. (1941): Geology of the Taesyongsan (Taiseizan) District near Phyongyang (In Japanese). Jour. Geol. Soc. Japan, Vol. 48, No. 570.

KOBATAKE, N. (1953): On the Heian System I (In Japan.). Sci. Rep. South Coll. Ôsaka Univ., No. 2.

KOBAYASHI, T. (1929): On the Ordovician System in South Manchuria and North Korea (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 36.

KOBAYASHI, T. (1930a): Ordovician Fossils from Korea and South Manchuria, Pt. II. On the Bantatsu Bed of the Ordovician Age. Jap. Jour. Geol. Geogr., Vol. 3-4.

KOBAYASHI, T. (1930b): Significance of the Unconformity at the Base of the Lower Daido Formation (In Japan.). Jour. Geol. Soc. Tôkyo. Vol. 37.

KOBAYASHI, T. (1931): Studies on the Ordovician Stratigraphy and Palaeontology of North Korea with Notes on the Ordovician Fossils of Shantung and Liautung.

Bull. Geol. Survey Korea, Vol. 11.

KOBAYASHI, T. (1933) : A Sketch of Korean Geology. Amer. Jour. Sci., Ser. v, Vol. 26.

KOBAYASHI, T. (1941): The Sakawa Orogenic Cycle and its Bearing on the Origin of the Japanese Islands. Jour. Fac. Sci. Imp. Univ. Tôkyo, Sec. II, Vol. V, Pt. 7.

KOBAYASHI, T. (1951) : General Remarks on the Geology of Japan (In Japan.). Asakura-shoten, Tôkyo.

KOBAYASHI, T. (1952a) : Heian Orogenic Belt of North Korea (In Japan.). Geology and Mineral Resources of East Asia.

KOBAYASHI, T. (1952b) : Chosen (Tyosen) System in the Heian Geosyncline (In Japan.) Geology and Mineral Resources of Eastern Asia. Korea I.

KOCHIBE, T. (1908) : Outline of the Coal Measure in the Vicinity of Phyongyang (In Japan.). Jour. Geogr. Tôkyo. Vol. 15.

KOGURE, K. (1920) : Macroscopic Observation of the Jidô Anthracite (In Japan.). Jour. Min. Assoc. Korea, Vol. 3.

KOGURE, K. (1935) : Phyongyang Anthracite and its Colour and Particle Form. (In Japan.) Mater. f. Phyongyang Anthracite, 1.

KOGURE, K. (1937) : Production Cost of the Korean Anthracite (In Japan.). Jour. Min. Assoc. Korea, Vol. 20.

KOIWAI, K. (1927) : On the Occurrence of a New Species of Neuropteridium in Korea and its Geological Significance. Sci. Rep. Tôhoku Imp. Univ. Vol. XI–1.

KOIWAI, K. (1932) : On Gigantopteris (In Japan.). Report of the Japan Society for the Promotion of Sciences Vol. 7.

KOIWAI, K. (1937) : On Ledidodendron oculis-felis (Abbado) Zeiller and its Allied Forms (In Japan.). Jour. Geol. Soc. Japan. Vol. 44.

KON'NO, E. (1928a) : Geologic Structure of the Western Part of the Phyongyang Coal Field (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 35.

KON'NO, E. (1928b) : On Tingia and Schizoneura from the Permian of Korea (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 35.

KON'NO, E. (1928c) : Coal Measure and Mode of Occurrence of Coal in the Western Part of the Phyongyang Coal Field (In Japan.). Coal News. Vol. 3.

KON'NO, E. (1929) : On Genera Tingia and Tingiostachya from the Lower Permian and the Permo-Triassic Beds in Northern Korea. Jap. Jour. Geol. Geogr., Vol. 6.

KON'NO, E. (1931a) : Anthracite of Korea (In Japan.). Geographic Education. Vol. 41.

KON'NO, E. (1931b) : Preliminary Notes on the Daidô System in Vincintiy of Phyongyang (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 38.

KON'NO, E. (1933) : Palaeozoic Plant Fossils (In Japan.). Iwanami Kôza.

KUROKI, Y. (1925) : On the Korean Coal (In Japan.). Korea. February Issue.

MAEJIMA, S. (1935) : Geology of Phyongyang (Preliminary Report) (In Japan.). Chikyû, Vol. 24.

MAEJIMA, S. and K. TAKIMOTO (1937) : Outline of Geology in the Vincinity of the

Kanpoku Colliery, Phyongyang Coal Field (In Japan.). Chikyû, Vol. 27.

MATSUDA, S. and S. SASAO (1906) : Report of the Mining Survey of Korea (Phyongam-do) (In Japan.). Ministry of Agriculture and Forestry.

MATSUSHITA, S. (1933) : Stratigraphy and Geologic Structure of the Northeast of Phyongyang (In Japan.). Chikyû, Vol. 20.

MATSUSHITA, S. (1937) : Peculiar Forms of the Phyongyang Anthracite Deposits (In Japan.). Jour. Geol. Soc. Japan, Vol. 45.

MATSUSHITA, S. (1938a) : Geologic Structure of the Northeast of Phyongyang and the Kôtô Distrcit (In Japan.). Jour. Geol. Soc. Japan, Vol. 45.

MATSUSHITA, S. (1938b) : The Anthracite Field of the Southern Part of S. Pyongam-do (In Japan.). Coal Field of Korea, Vol. 13.

MATSUSHITA, S. (1941) : Correlation between the Syōgen System in the Central Area of Kōkai-dō, Korea and the Sinian System in the Kuantung Province, South Manchuria. Jap. Jour. Geogr., Vol. XVIII, No. 1—2.

MATSUSHITA, S. (1943) : Stratigraphy and Structure of the Shôgen System in the Central Area of Kôkai-dô, Korea. Sc. Rep., Geol. Miner. Inst. Kyotô Imp. Univ., 2.

MATSUSHITA, S., KOBATAKE, N. and N. IKEBE (1952) : Thrust Structure of the Phyongyang Coal Field, Korea (In Japan.). Jour. Geol. Soc. Japan, Vol. 58.

MIZUTANI, K. (1923) : On the Exploitation of the Phyongyang Coal Field (In Japan.). Jour. Min. Assoc. Korea, Vol. 6.

NAKAMURA, S. (1918) : Jidô Thrust (In Japan.). Jour. Geol. Soc. Tokyo, Vol. 25.

NAKAMURA, S. (1925) : Peneplain to the South of Phyongyang: Rakuroan Peneplain (In Japan.). Chikyû, Vol. 3.

NAKAMURA, S. (1926) : Stratigraphy and Geologic Structure of the Proterozoic and Cambrian Systems of the Shôgen District, Korea (In Japan.). Chikyû, Vol. 6.

NAKAMURA, S. (1927) : Introduction to the Geotectonics of Korea (In Japan.), Chikyû, Vol. 8; Rep. Japan. Soc. Promot. Sci., Vol. 3.

NAKAMURA, S. (1932a) : Complicated Structure of the South of the Phyongyang Coal Field (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 39.

NAKAMURA, S. (1932b) : Stratigraphical Study on the Cambrian System of Korea (In Japan.). Imperial Academy of Japan.

NAKAMURA, S. (1935) : Geologic Structure of the Phyongyang Coal Field (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 42.

NAKAMURA, S. (1936a) : Outline of the Geologic Structure of the Western Part of the Phyongyang Coal Field (In Japan.). Chikyû, Vol. 25.

NAKAMURA, S. (1936b) : Second Note on the Geologic Structure of the Phyongyang Coal Field (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 43.

NAKAMURA, S. (1938) : Third Note on the Geologic Structure of the Phyongyang Coal Field (In Japan.). Jour. Geol. Soc Japan, Vol. 45.

NAKAMURA, S. and S. MATSUSHITA (1939) : Pre-Cambrian in Manchuria and Korea. Proc. Sixth Pacific Science Congress.

NISHIWADA, K. (1898) : Report of the Mineral Survey of Korea (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 5.

OISHI, S. (1931a) : Fossil Plants from Japan and Korea. Sci. Rep. Tohoku Imp. Univ. Vol. 14.

OISHI, S. (1931b) : A New Type of Fossil Cupular (?) Organ from the Jidô Series of Korea. Jap. Jour. Geol. Geogr., Vol. VIII–4.

OZAKI, K. (1934) : On Some Brachiopods from the Reddish Purple Shale of the Kôten Series exposed in the Heizyô Coal-Field. Jour. Shanghai Science Inst., Sec. II.

OZAWA, Y. (1927) : Some Carboniferous Fossils Collected in Manchuria and Korea. Jap. Jour. Geol. Geogr., Vol. V–3.

SAKAKURA, K. (1936) : Cambrian on the Southeast Side of the Jidô Thrust (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 43.

SAITO, K. (1933a) : Cambrian System of the Chunghwa District, Korea (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 40.

SAITO, K. (1933b) : The Occurrence of Protolenus in the Cambrian Rccks of North Korea. Jap. Jour. Geol. Geogr. Vol. 10.

SAITO, K. (1934) : Older Cambrian Trilobita and Conchostraca from Northwestern Korea. Jap. Jour. Geol. Geogr. Vol. 11.

SAITO, K. (1936) : Older Cambrian Brachiopoda, Gastropoda, etc. from Northwestren Korea. Jour. Fac. Sci. Imp Univ. Tôkyo, Sec. 2. Vol. 4, pt. 3.

SAWADA, H. (1941) : Geology of the Northwest Part of the Kantong-myon, Tyunghoa County, S. Pyongam-do, Korea (In Japan.). Jour. Gaol. Soc. Japan., Vol. 48.

SCHULZ, K. (1910) : Beiträge zur Petrographie Nord-Koreas. Neues Jahrb. Geol. Min. Pal., XXIX, Beil. Bd.

SHIMAKURA, M. (1934) : Studies on the Fossil Wood (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 41.

SHIMAKURA, M. (1936) : Studies on Fossil Woods from Japan and Adjacent Lands, Contribution I. Sci. Rep. Tôhoku Imp. Univ., Ser. V. Vol. 18.

SHIMAKURA, M. (1937a) : Outline of Mesozoic Woods of East Asia (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 44.

SHIMAKURA, M. (1937b) : Jurassic Erect Stumps unearthed at the 77th Regiment of Heizyô, Korea. Jour. Geol. Soc. Tôkyo, Vol. 44.

SHIMAMURA, S. (1929) : Geological Atlas of Chosen, No. 8. Geological Survey, Governor General of Chosen.

SHIMIZU, S. and T. OOSE (1939) : On the Classification of the Heian System, Korea (In Japan.). Jour. Geol. Soc. Japan, Vol. 46, No. 549.

SHIMIZU, S. (1940–41) : Geology of the Anthacite-fields of Tyôsen with Remarks on Anthacite Seams. (In Japan.) Ibidem.

TAKAHASHI, E. (1952) : Extension of Mukakuzan-Angaku Fault (In Japan.). Jour. Geol. Soc. Japan, Vol. 58.

TAKAHASHI, E. (1954) : Collenia Limestone from Syangwon in South Pyongam-do, Korea (In Japan.). Mineralogy and Geology, Vol. 3.

TAKAHASHI, E. (1956) : Geology of the Pöngnam-Hoanghai Orogenic Zone, No. 3–4 (In Japan.). Yamaguchi Jour. Sci., Yamaguchi Univ. No. 7.

TAKAHASHI, E. (1956) : Notes on some Stratigraphy of Corea (In Japan.). Yamaguchi Jour. Sci. Yamaguchi Univ. No. 7.

TAKEHARA, H. (1939) : Geology of the Syncline District of Hwangju, Hwanghae-do, Korea (In Japan.). Chikyū, Vol. 22.

TAMURA, E. (1917) : South Pyongam-do (In Japan.). Bull. Min. Surv. Korea, Vol. 2.

TATEIWA, I. (1924) : Geological Atlas of Chôsen, No. 2. Geological Survey, Governor General of Chôsen.

TATEIWA, I. (1929) : Geological Atlas of Chôsen, No. 10.

TATEIWA, I. (1931) : Geological Atlas of Chôsen, No. 12.

TATEIWA, I. (1952a) : On the Geologic Structure of the Korean Direction (In Japan.). Jour. Geol. Soc. Japan, Vol. 58.

TATEIWA, I. (1952b) : Cenozoic Crustal Movements and the Morphological Evolution in North Korea (In Japan.). Geology and Mineral Resources of East Asia.

TOKUNAGA, S. (1913a) : On the Palaeozoic Coal-bearing Formations of Manchuria and Korea (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 20.

TOKUNAGA, S. (1913b) : On the Geology of the Phyongyang Coal Field, Korea (In Japan.). Jour. Geogr. Soc. Tôkyo, Vol. 25.

TOKUNAGA, S. (1914) : Note on the Geological Age of Phyöng-yang Coal Field, Jour. Geol. Soc. Tôkyo, Vol. 21.

TSUCHIDA, S. (1941) : Form of the Anthracite Seams in the Vicinity of Fuklyongsan, Phyongyang Coal Field (In Japan.). Sci. Rep. Daidô Techn. Coll. Vol. 1.

UCHIDA, K. (1929) : On the Coal Fields of Korea (In Japan.). Jour. Fuel Assoc., No. 85.

YABE, H. (1906) : A Contribution to the Genus Fusulina, with Notes on a Fusulina-Limestone from Korea. Mem. Coll. Sci. Tokyo Imp. Univ., Vol. 21.

YABE, H. (1914) : Coal-Measures developed in Korea (In Japan.). Monthly Rep. Governer General of Korea, Vol. 4.

YABE, H. and I. HAYASAKA (1915) : Palaeozoic Corals from Japan and China. Jour. Geol. Soc. Tôkyo, Vol. 22.

YABE, H. (1917) : Geological and Geographical Distribution of Gigantopteris with Descriptions of three Asiatic Species by K. KOIWAI. Sci. Rep. Tôhoku Imp. Univ., Ser. II, Vol. VII, No. 2.

YABE, H. (1919) : Report of the Geological Survey on the Anthracite-bearing Formations of South Pyongam-do, Korea (In Japan.). Bull. Geol. Surv. Korea, Vol. I, No. 1.

YABE, H. (1922) : Notes on Some Mesozoic Plants from Japan, Korea and China, in the Collection of the Institute of Geology and Palaeontology of the Tôhoku Imperial University, I. Sci. Rep. Tôhoku Imp. Univ., Ser. II, Vol. 7, No. 1.

YABE, H. and S. OISHI (1929) : Notes on Some Fossil Plants from Korea and China belonging to the Genera Nilssonia and Pterophyllum. Jap. Jour. Geol. Geogr., Vol. 6, No. 3–4.

YABE, H. and S. OISHI (1930) : Desmopteris (?) orientalis n. sp. from the Kôbôsan District of Corea. Jap. Jour. Geol. Geogr., Vol. 8, No. 1–2.

YABE, H. and T. SUGIYAMA (1930) : On Some Ordovician Stromatoporoids from South Manchuria, North China and Chôsen (Korea), with Notes on Two Nev European Forms. Sci Rep. Tôhoku Imp. Univ., Ser. II, Vol. 14, No. 1.

YOKOYAMA, M. (1906) : Age of Phyongyang Coal of Korea (In Japan.). Jour. Geol. Soc. Tôkyo, Vol. 13.

Appendix 1

Description of Plants

By

Nobuo KOBATAKE

More than 170 fossil plants have been reported from the Heian System of Korea, and even in the Phyongyang (Heijô) Coal Field nearly 75 species have been found. Some of the plants listed in the foregoing paragraph have not yet been described before and are considered as new species. The writer wishes to give brief description on these new plants.

All these plants are the members of the Kôbôsan flora and most of them have been collected in the Kôbôsan district by the writer.

Sphenophyllum kôbôense sp. nov.
Pl. XXIII Figs. 6-8, Pl. XXIV Figs. 4, 5.

Stem somewhat thick, 4-4.5 mm across, slightly tumid at node, with a few longitudinal grooves. The internodal length is 30 mm in some specimen. Leaflets rather large, vary much in size and shape, obovate, rhombic or broadly lanceolate, but this difference may not be so great originally. They are 6 in a verticil and arranged in 3 pairs and attached to the stem considerably spreadingly. The upper 2 pairs are almost isophyllous while the lower leaflets are smaller and suborbicular in shape. The anterior half of the margin of larger leaves is round or bluntly pointed, finely repand or sharrowly dissected, but in the posterior part there is a median depression and the margin entire.

Veins crowded and a remarkably thick nerve, comparably to a mid-nerve, persists for about half of its course to the apical end, then splits into many veinlets, which repeat bifurcation and end at the distal margin. Several lateral veinlets, some of which are given off directly from the base run parallel to the midnerve for some distance, then curve strongly outward and before ending at the lateral margin again bend foreward, but in narrow leaves the curving of the veins is not so strong. The number of veins along the distal margin is 20-30 in 1 cm.

The detached leaves of the present species are much like those of *Sphenophyllum Thonii* Mahr or *S. Thonii* Mahr var. *minor* Sterz., but in the latter two all leaflets are isophyllous and lack midvein. Halle's ? *Sphenophyllum sino-coreanum* Yabe (1927 Pl. 9, Figs. 14-16) seems to come very near to this species and Kawasaki's *Sphenophyllum* sp. (1931 Pl. XVIII Fig. 13) is, as pointed out by him, other than Yabe's or Mahr's species and is most probably identical with present species.

Sphenophyllum grandifolium sp. nov.
Pl. XXIII Fig. 5.

Stem thick, measuring 5 mm wide with some logitudinal striation, the internodal length unknown.

Leaves are disposed verticillately in 3 pairs at a node. The upper pairs are nearly perpendicular to the stem and leaves oblong-cuneate, very large, more than 70 mm long and at least 15 mm wide in some specimen and the lateral margin entire, but apical part crenulate; the lower pair attaches to the stem pendingly at the node, broadly cuneate and in the same specimen mentioned above 25 mm long and 17 mm broad in the distal part.

Veins dense, several primary ones are borne at the base, bifurcate 3 or 4 times, run parallel to the margin and most ultimate veinlets terminate at the apical part and numbers about 25 per 1 cm.

Plagiozamites Nakamurai sp. nov.
Pl. XXIV, Fig. 1-2.

Frond large pinnate, broadly lanceolate, probably more than 1 m long and 30 cm broad at most, tapering towards both ends. Rachis very thick, about 2 cm wide with fine logitudinal striations.

Leaves linear-lanceolate or lanceolate, attached semi-amplexicaully to the lateral side of the stem, making an angle of about 50° in normal position, 15 cm long and 2.5 cm wide in the broadest part of the frond. Lateral margin entire and remarkably truncated at distal end. In the middle part of the frond they are closely disposed, slightly overlapping the adjacent one, but in the basal part rather sparcely set. The truncated end of the leaf splits into nearly equal teeth of blunt apices. This character is especially fully observed on the laminae of the middle part of the frond.

Veins parallel, dense but rather thin in proportion to the size of lamina, about 35 to 1 cm. in the middle part of normal leaves. Bifurcation occurs only at the base and every apical segment receives several veinlets, which converge to the end of the segment.

The general appearance of the frond reminds the author of the genera *Tingia* and *Pterophyllum*. Of the former genus the present specimen resembles very much to *T. carbonica* Halle and *T. crassinervis* Halle in the point of apical feature. But the four-rows arrangement of leaves, the generic character of the genus, the author failed to find on this material and its semi-amplexicaul insertion of laminae to the flank of the stem seems to be inconsistent with the dorsiventral phyllotaxis of *Tingia*. *Pterophyllum* is also put aside for the mode of attachment of its pinnae on the lateral side of the stem. Close resemblance is recognized to *Plagiozamites longifolius* Kawasaki but the present specimen differs from Kawasaki's in the point of large leaves and nature of their apices.

To this plant *Plagiozamites Nakamurai* is proposed in honour of the late Prof. Nakamura, a great authority on the Korean geology and by whose recommendation the writer began to study the Heian System and its flora.

Appendix 2

List of place names used in this article showing the comparison between the names written in Roman letters and those written in Chinese characters.

(Roman letters after Japanese pronounciation are in solid, while those after Korean pronounciation are in italic.)

Roman letters	Chinese characters
Alnemi	鴨 蹄
Angaku (*Anak*)	安 岳
Antyongni (Anjôri)	安静里
Banryûdô (*Bangyongdong*)	盤竜洞
Bundô (*Mundong*)	文 洞
Chaelyonggang (Saineikô)	載寧江
Chôsen	朝 鮮
Chûwa (*Tyunghoa*)	中 和
Cholkol (Jidô)	寺 洞
Daidô (*Taedɔng*)	大 同
Daiseizan (*Taesyongsan*)	大聖山
Dokyô (*Tokyo*)	土 橋
Fukkyo (Kokkyô)	黒 橋
Fuknongsan (Kokuryûsan)	黒竜山
Haksanni (Kakusanri)	鶴山里
Heijo (*Phyongyang*)	平 壌
Hoachonli (Kasenri)	貨泉里
Hôkari (*Panghoali*)	芳花里
Hôwô-san (*Ponghoansan*)	鳳凰山
Hyonkyoli (Genkyôri)	絃橋里
Imwon-myon (Ringen-men)	林原面
Jôtôgansan (*Songtuamsan*)	城頭岩山
Kampoku (*Kampuk*)	坎 北
Kangdong, Kangtong (Kôtô)	江 東
Kangso (Kôsai)	江 西
Kasekiri (*Hoasyokli*)	花石里
Kinsai-men (*Kumtyoe-myon*)	金祭面
Kiyô (*Kiyang*)	岐 陽
Kôkaidô (*Hoanghae-do*)	黄海道
Kôjinsan (*Kangjinsan*)	江津山
Kolyongsan (Kôreisan)	高霊山
Kongpho-myon (Kôhomen)	公浦面
Anak (Angaku)	安 岳
Anjôri (*Antyongni*)	安静里
Bangyongdong (Banryûdô)	盤竜洞
Bantatsusan (*Mantalsan*)	晩達山
Chigansan	雉岩山
Chôheizan (*Tyangphyongsan*)	長平山
Chôzan (*Tyangsan*)	長 山
Chyuam (Shugan)	酒 岩
Chyongunsan (Seiunzan)	青雲山
Daidôkô (*Taedonggang*)	大同江
Daitatsuri (*Taetalli*)	大達里
Eisenri (*Yongchongli*)	永川里
Fuklyongsan (Kokureisan)	黒嶺山
Genkôri (*Wonhyoli*)	源孝里
Heian (*Phyongan*)	平 安
Henhyondong (Kôkendô)	香峴洞
Hoangkyongtong (Kôkyôdô)	黄京洞
Hôtô-san (*Pongtusan*)	鳳頭山
Hûo-san (Pongwosan)	楓於山
Inken (*Wonhyon*)	院 峴
Jidô (*Sadong*)	寺 洞
Junwakô (*Sunhoagang*)	順和江
Kampuk (Kampoku)	坎 北
Kangjinsan (Kôjinsan)	江津山
Kanshiri (*Konchili*)	乾芝里
Kasenri (*Hoachonli*)	貨泉里
Kiyang (Kiyô)	岐 陽
Kobangsan (Kôbôsan, Kobôsan)	高坊山, 古坊山
Kokureisan (*Fuklyongsan*)	黒嶺山
Konchili (Kanshiri)	乾芝里
Kopili (Kôhiri)	高飛里

Roman letters	Chinese characters
Kôrei-san (*Kolyongsan*)	高霊山
Kôtei-san (*Kotyongsan*)	高亭山
Kotyongsan (Kôteisan)	高亭山
Kuken (*Kuhyon*)	駒 峴
Kumtyoe-myon (Kinsaimen)	金祭面
Malan (Baran)	馬 嵐
Mantalsan (Bantatsusan)	晩達山
Momodani	桃 谷
Moktantae (Botandai)	牡丹台
Momatsusan (*Mosusan*)	母末山
Mukakusan (*Muhaksan*)	舞鶴山
Mulpi (*-kol*) (Suinyû (-dô))	水入（一洞）
Munsanli (Monsanri)	文山里
Myonglyaweli (Meireiri)	明礼里
Namkang (Nankô)	南 江
Namkyongli (Nankinri)	南京里
R. Nankô (*Namkang*)	南 江
Nongaksan (Ryûgakuzan)	竜岳山
Nongtyong (*-ni*) (Ryûsei (-ri))	竜井（一里）
Odong (Godô)	梧 洞
Panghoali (Hôkari)	芳花里
Pemichyon (Ritsurisen)	栗里川
Phyongyang (Heijô)	平 壌
Ponghoansan (Hôwôzan)	鳳凰山
Pongwosan (Fûozan)	楓於山
Pusan-myon (Fuzanmen)	斧山面
Ritsuri (*Yulni*)	栗 里
Ryûsei (-ri) (*Nongtyong-ni*)	竜井（一里）
Saireiri (*Tyawelyongni*)	祭霊里
Samsandong (Sanzandô)	三山洞
Samtung (Santo)	三 登
Sangnong-myon (Sôryûmen)	双竜面
Santo (*Samtung*)	三 登
Sekirinri (*Syoknumni*)	石廩里
Shidôgû (*Sadangmol*)	祠堂隅
Shinmadô (*Sinmatong*)	新麻洞
Shôgairi (*Syongkoli*)	松街里
Shôreisan (*Sunglyongsan*)	承嶺山
Sinmatong (Sinmadô)	新麻洞
Songtuamsan (Jôtôgansan)	城頭岩山

Roman letters	Chinese characters
Kôsai (*Kangso*)	江 西
Kôtô (*Kangdong, Kangtong*)	江 東
Kuhyon (Kuken)	駒 峴
Kuloli (Kyûrôri)	九郎里
Madenpo (*Sanbatsmol*)	麻田浦
Mantalhyon (Bantatsuken)	晩達峴
Masanni (Masanri)	馬山里
Monsanri (*Munsanli*)	文山里
Mosusan (Momatsusan)	母末山
Muhaksan (Mukakusan)	舞鶴山
Mulpanakan? (Suitandô)	水砧洞
Monnai (-dô) (*Munnei* (*-kol*))	文内洞
Munnei (*-kol*) (Monnai (-dô))	文内洞
Muntong (Bundô)	文 洞
Namhyongdyoesan-myon (Nankeiteisanmen)	南兄弟山面
Namsandong (Nanzandô)	南山洞
Nanzandô (*Namsandong*)	南山洞
Nongtang (Ryûdô)	竜 塘
Nongsyong (Ryûjô)	竜 城
Nosyongni (Roseiri)	魯聖里
Okkapong (Gyokkahô)	玉珂峯
Pansyok-myon (Hansekimen)	班石面
Phongdong-myon (Fûdômen)	楓洞面
Pisyokkol (Hisekidô)	碑石洞
Pongtusan (Hôtôzan)	鳳頭山
Pultangkol (Butsudôdô)	佛堂洞
Ringen-men (*Imwon-myon*)	林原面
Ritsurisen (*Pemichyon*)	栗里川
Sadangmol (Shidôgû)	祠堂隅
Saineikô (*Chaelyonggang*)	載寧江
Saireizan (*Tyawelyongsan*)	祭霊山
Samsintong (Sanshindô)	三神洞
Sanbatsmol (Madenpo)	麻田浦
Sanshindô (*Samsintong*)	三神洞
Sebangsyong (Shinbôjô)	新坊城
Senken	嬋 妍
Shinbôjô (*Sebangsyong*)	新坊城
Shinsô (*Sinchang*)	新 倉
Shôgen (*Syangwon*)	祥 原
Sinchang (Shinsô)	新 倉
Sityok-myon (Shisokumen)	柴足面
Soryûmen (*Sangnong-myon*)	双竜面

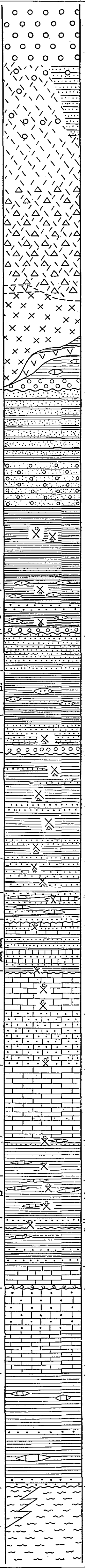
Roman letters	Chinese characters
Suinyû (-dô) (*Mulpi* (*-kol*))	水入(一洞)
Sungholi (Shôkori)	勝湖里
Sutyongtyon (Suishôsen)	水晶川
Syoknumni (Sekirinri)	石廩里
Syongsanni (Seizanri)	聖山里
Syungtokli (Sûtokuri)	崇徳里
Taechonni (Taisenri)	大泉里
Taejawon (Taishiin)	太子院
Taesongli (Taiseiri)	大成里
Taesyongsan (Daiseizan)	大聖山
Taihô (-men), (-san) (*Taepo* (*-myon*), (*-san*))	大宝(一面), (一山)
Takkabô (*Talkabong*)	達河峯
Talpakkol (Getsumeidô)	月明洞
Tamokuri (*Tamokli*)	多木里
Tokamli (Tokuganri)	徳岩里
Tokuganri (*Tokamli*)	徳岩里
Tolpaksan (Sekihakusan)	石礡山
Tudasa (Zudaji)	頭陀寺
Tyangphyongsan (Chôheizan)	長平山
Tyangsyuwon (Chôsuiin)	長水院
Tyawelyongsan (Saireizan)	祭靈山
Tyunghoa (Chûwa)	中 和
Wonhyoli (Genkôri)	源孝里
Wontan-myon (Gentan-men)	元灘面
Yongtok (Yôtoku)	陽 徳
Yonhoani (Renkari)	蓮花里
Yûken	酉 峴
Yulni-myon (Ritsurimen)	栗里面
Suitandô (*Mulpanakan*)	水砧洞
Sunglyongsan (Shôreisan)	承嶺山
Syangwon (Shôgen)	祥 原
Syongkoli (Shôgairi)	松街里
Syongwoli (Shôwori)	松堣里
Syunghoakang (Junwakô)	順和江
Taedonggang (Daidôkô)	大同江
Taepo (*-myon*), (*-san*) (Taiho (-men), (-san))	大宝(一面), (一山)
Taetyangli (Daisôdô)	大荘洞
Taisenri (*Taechonni*)	大泉里
Taishiin (*Taejawon*)	太子院
Talkabon (Takkabô)	達河峯
Tamokli (Tamokuri)	多木里
aetalli (Daitatsuri)	大達里
Toksan (Tokusan)	徳 山
Tokyo (Dokyô)	土 橋
Tongsoni (Tôzairi)	東西里
Tumkol (Tomudô)	斗武洞
Tyangsan (Chôzan)	長 山
Tyawelyongni (Saireiri)	祭靈里
Tyongsan (Zenzan)	全 山
Wolpongsan (Geppôsan)	月峰山
Wonhyon (Inken)	院 峴
Yongchongli (Eisenri)	永川里
Yongdong (Yôdô)	陽 洞
Yôtoku (*Yongtok*)	陽 徳
Yukyong (Ryûkyô)	柳 京
Yusinli (Ryûshinri)	柳新里

Geologic Map of the Phyongyang coal Field, Korea (1 :100,000)

GEOLOGICAL MAP OF PHYONGYANG (HEIJÔ) COAL FIELD

平壌炭田地質図

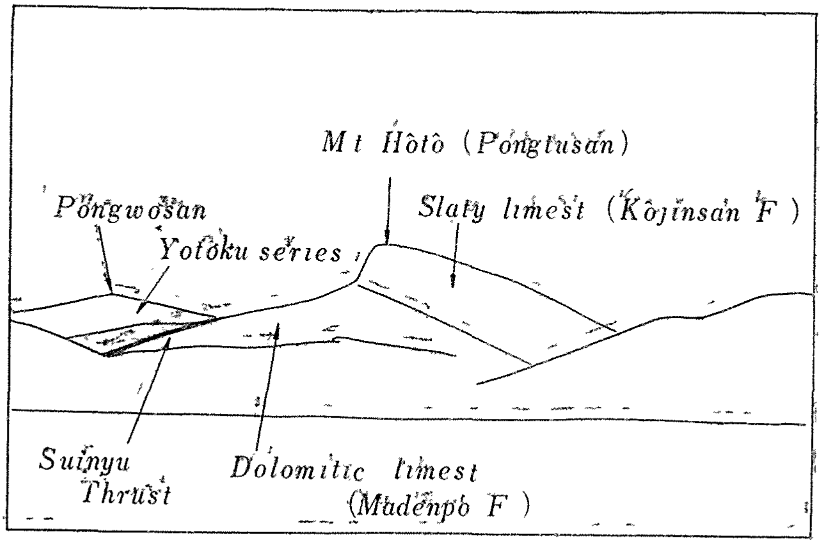
Compiled by S. Nakamura in 1940
Revised by S. Matsushita, N. Kobatake and N. Ikebe in 1956

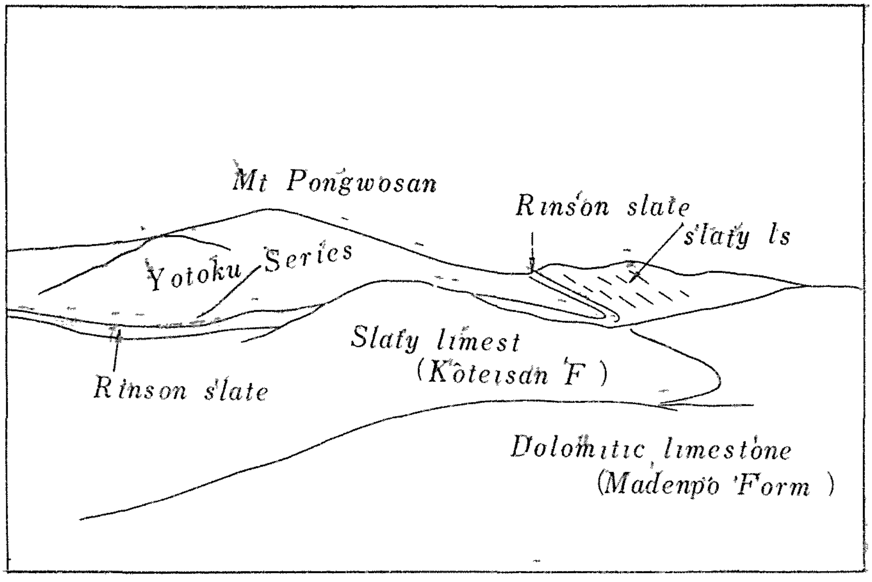


Age		Stratigraphy			Thickness in meters	Lithology
Cretaceous		Taihô System			2000	Conglomerate Tuff-conglomerate Tuff-breccia Porphyrite, quartz-porphyrite Reddish shale w. lenticular sandstones Basal conglomerate
Jurassic	M L	Daidô System	Upper		1300	Alternations of compact shale and medium-grained sandstone Conglomeratic sandstone Black compact shale
——?——			Lower	d c b a		d: Black shale w. lenticular sandstones c: Quartz sandstone b: Black shale w. lenticular q-sandstone a: Basal conglomerate
Triassic	U L	Heian System	Taishiin Series	Yôdô Bed	650	Whitish grey micaceous medium-grained sandstone with shale
——?——				Sanseiri Bed		Shale and sandy shale with lenticular sandstone
				Godô Bed		Green and red brown shale Sandstone with shale Basal conglomerate
Permian	U		Kôbôsan Series		max. 600	Yellowish brown or grey shale White quartzose sandstone
	M		Upper Jidô Series		200	Grey black shale and micaceous sandstone with workable coal seams
	L		Lower Jidô Series		max. 150	Shale and sandstone with limestone, chert and coal
Carbon-iferous (Moscovian)			Kôten Series	d c b a	250–300	d: Limestone and chert c: Yellow, red and green shale and sandstone b: Limestone and chert a: Red, purple shale (Alnemi shale)
Ordo-vician	M	Chôsen System — Great Limestone Series	Ban-tatsu Series	Kôjinsan Stage	200–450	Platy limestone and cloudy limestone
	L			Madenpo Stage	300–400	Dolomite accompanied by dolomitic limestone
Cam-brian	U		Kôrei-san Series	Kôteisan Stage	320–500	Thin platy limestone
				Rinson Stage	10–120	Black shale or slate with lenticular limestones
	M	Chôsen System	Yôtoku Series	Shôra Stage — Masanri Bed	150 (350 ~ 700)	Greenish shale or phyllite with lenticular limestones, Fukadani ss. at the top
	L			Shôra Stage — Rakumin Bed	200–500	Greenish or purplish shale or green phyllite with lenticular limestones
				Monsanri St.	10–150	Quartzite and reddish shale
Proterzoic		Shôgen System	Kuken Series*		200 (310)	Black slate with siliceous slate or quartzite and lenticular limestones
					100	Thin platy limestones
					10	Slate or *Collenia* limestones
			Shidôgû Series		400–700	Dolomite Thin platy limestone
			Chokken Series		510–700	Green phyllite with lenticular limestones Quartzite Quartzite
?		Keirin System				Keirin System: mica-schist, mica-gneiss, phyllite, quartzite etc.
		Kokulian Granite				Kokulian Granite: biotite-gneiss and schistose biotite-granite.

Generalized Columnar Section of the Major Geological Formations of the Phyongyang Coal Field

* See the postscript on p. 31.


Mt Hôtô (Pongtusan)
Pongwosan
Slaty limest (Kojinsan F)
Yotoku series
Suinyu
Thrust
Dolomitic limest
(Madenpo F)


Mt Pongwosan
Rinson slate
slaty ls
Yotoku Series
Slaty limest
(Kôteisan F)
Rinson slate
Dolomitic limestone
(Madenpo Form)

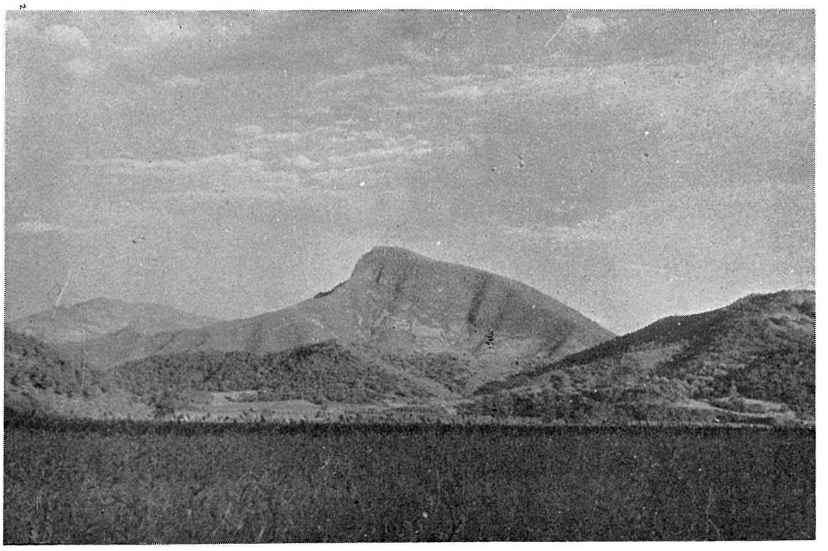


Fig. 1 View of Mt. Pongtusan (Hôtô-san) north of Samtung, seen from north, showing the stratigraphic successions and structures of the Chôsen System, in the eastern margin of the mapped area.

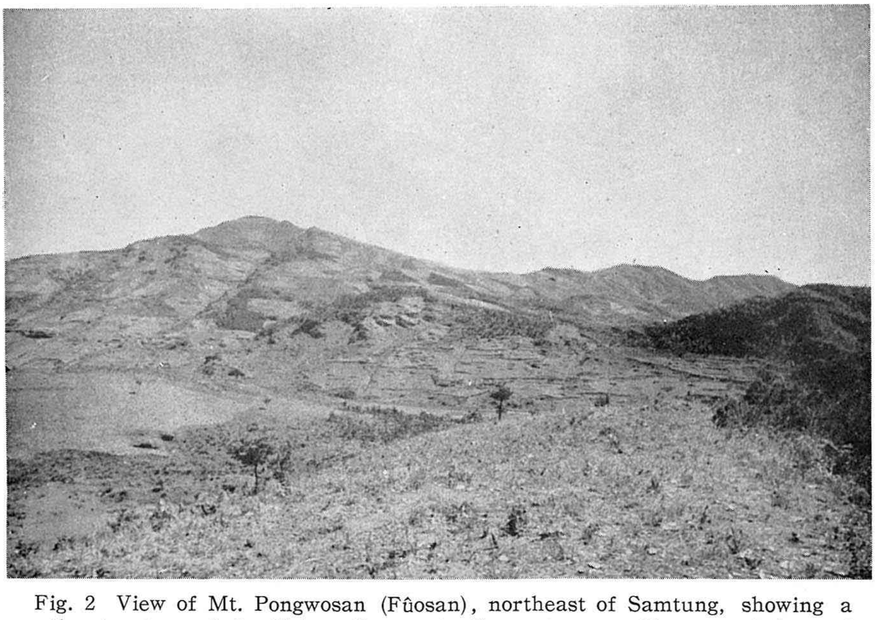


Fig. 2 View of Mt. Pongwosan (Fûosan), northeast of Samtung, showing a gentle structure of the Chôsen System in the eastern outside area of the coal field.

Fig. 1 An outcrop of the slaty limestone of the Kôjinsan formation, Bantatsu Series (Ordovician), at Panghoali (Hôkari), south of Samtung.

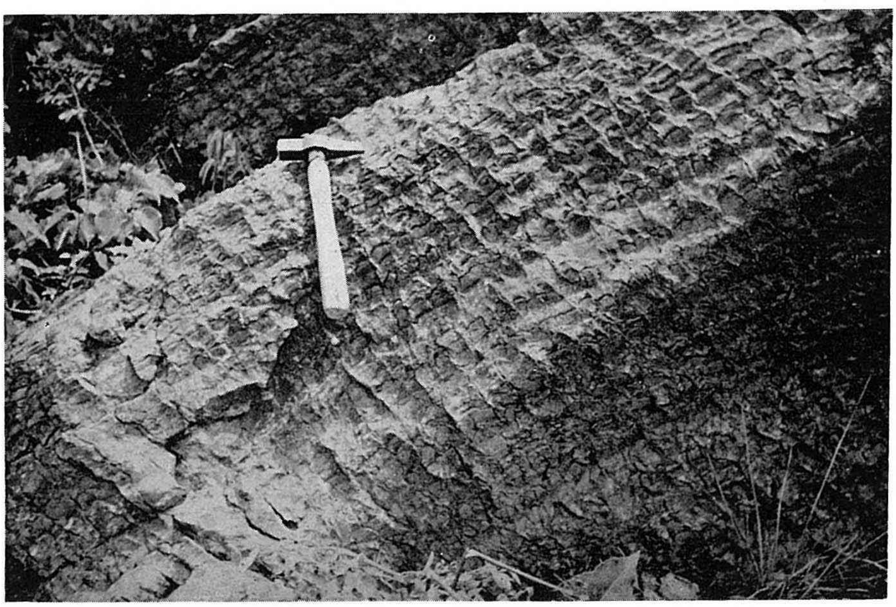
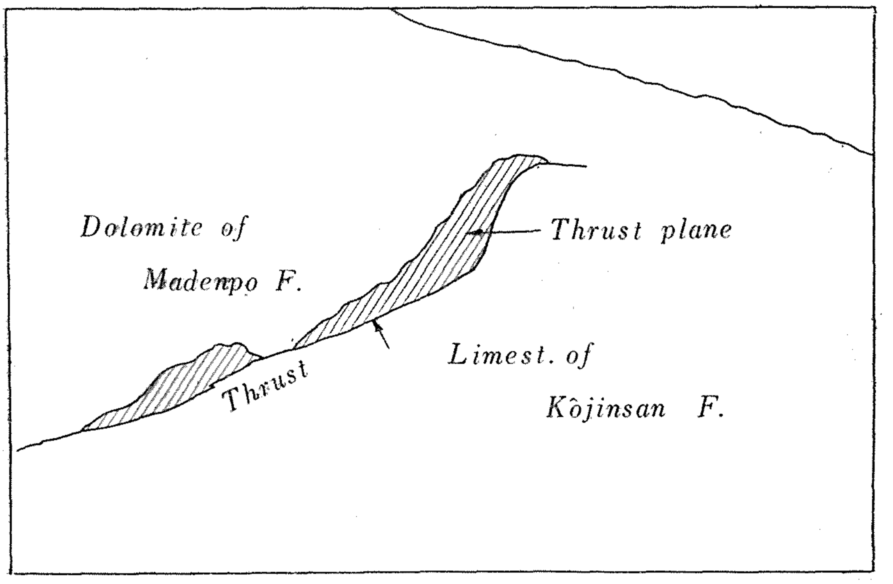


Fig. 2 An outcrop of the banded limestone of the Upper Cambrian Kôteisan formation, Kôreisan Series, exposed at Tok-am li (Tokuganri), north of Mt. Kolyongsan.


Dolomite of
Madenpo F.
Thrust plane
Thrust
Limest. of
Kôjinsan F.

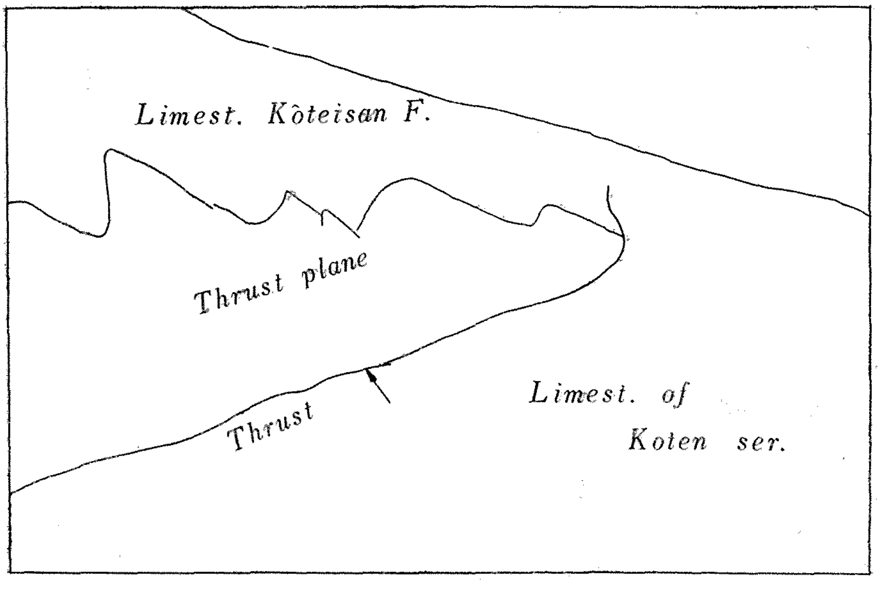

Limest. Kôteisan F.
Thrust plane
Thrust
Limest. of
Koten ser.

Fig. 1 An outcrop of the Suinyû thrust exposed at the south of Wonhyoli, between Kangtong and Samtung.

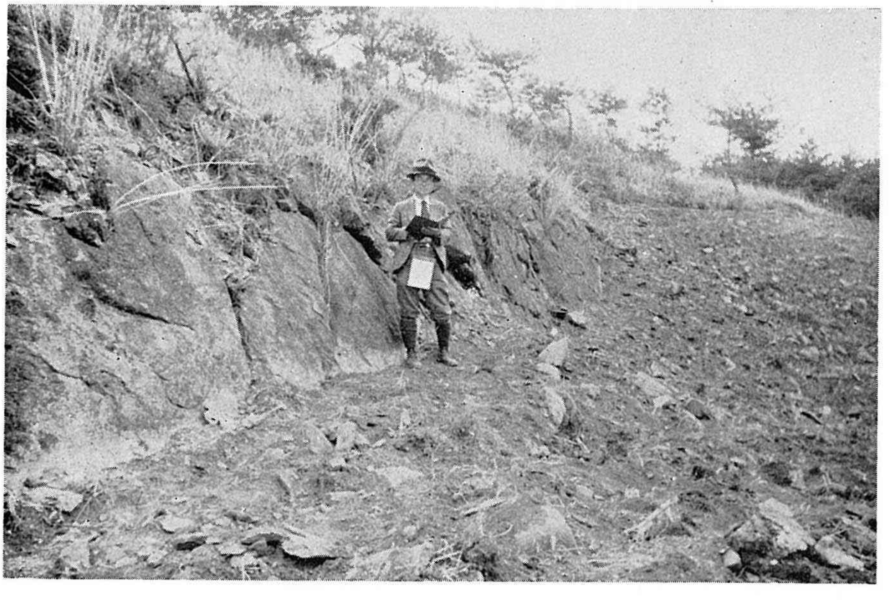
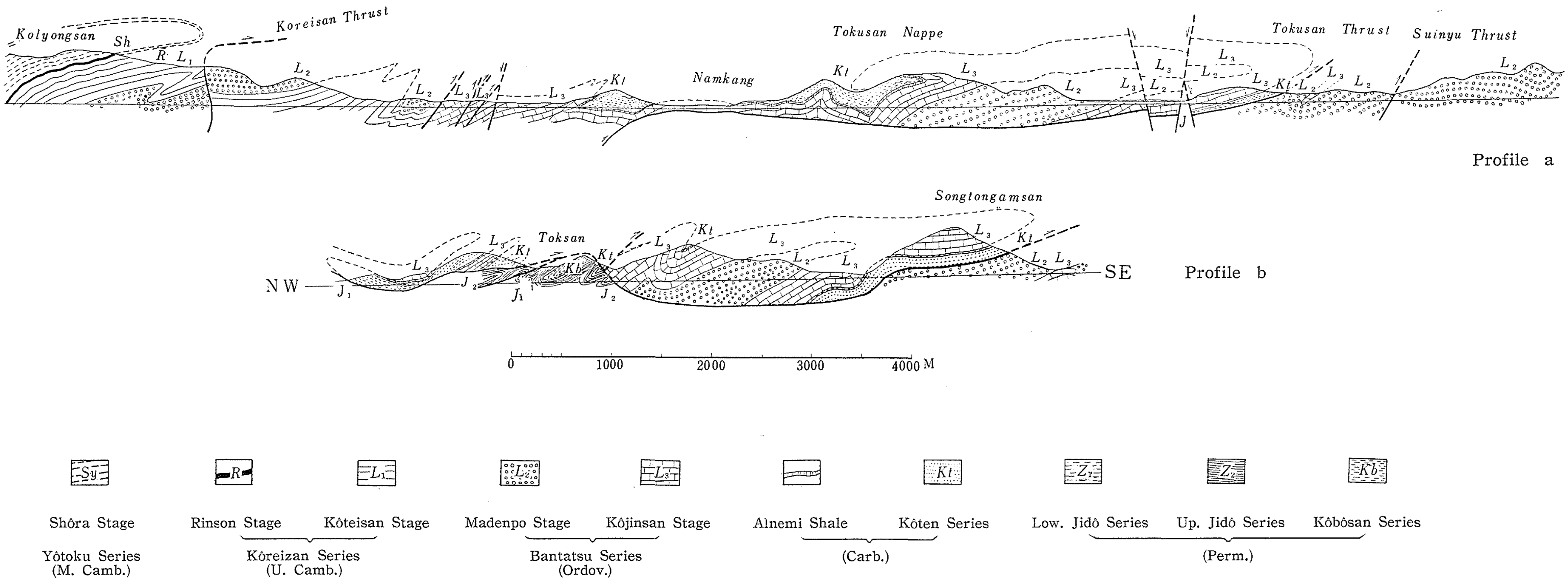


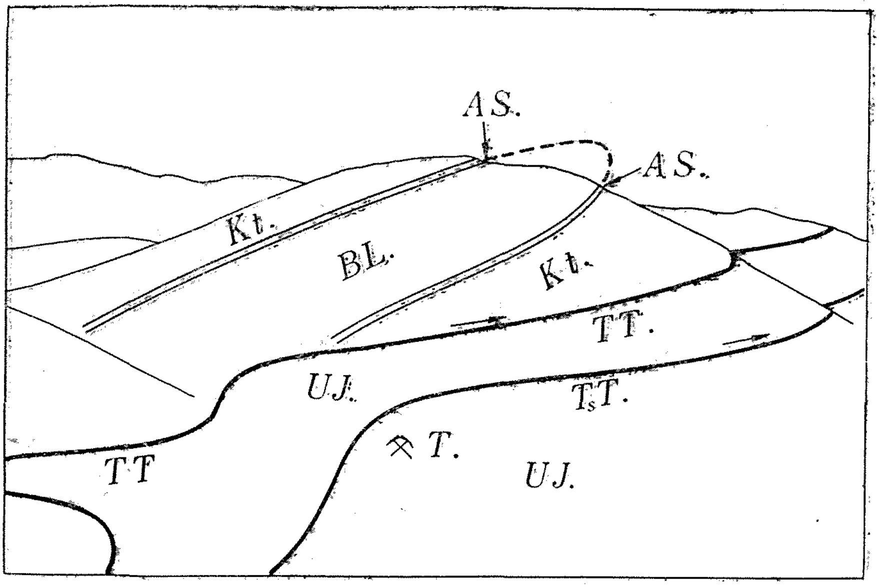
Fig. 2 An outcrop of the Suinyû thrust exposed at Syoknumni, between Kangtong and Samtung.

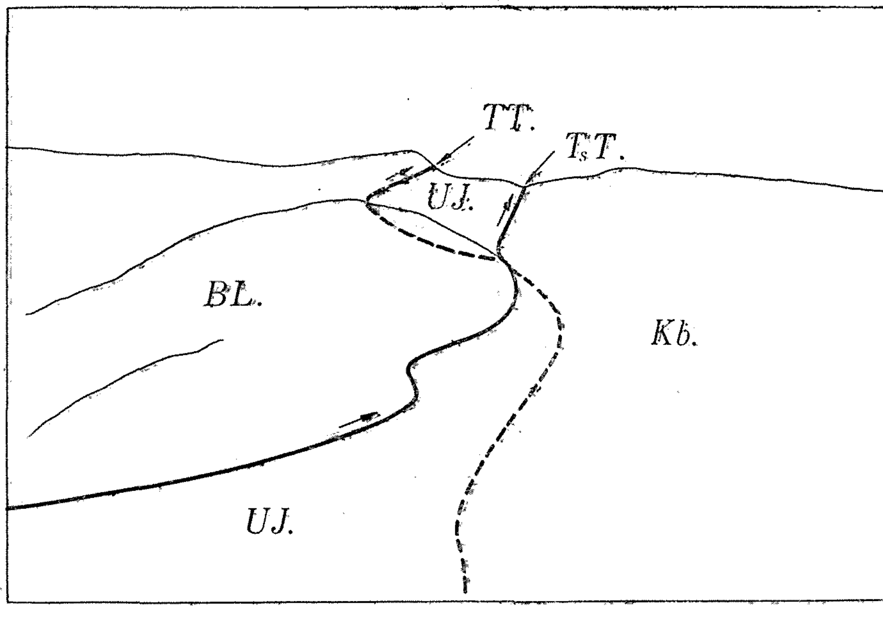
Pl. V



Profiles of the Tokusan Nappe

a. N 58°E through Kolyongsan
b. N 50°W through Toksan


A.S.
A.S.
Kt.
BL.
Kt.
TT.
UJ.
T_sT.
T.
TT
UJ.


TT.
T_sT.
UJ.
BL.
Kb.
UJ.

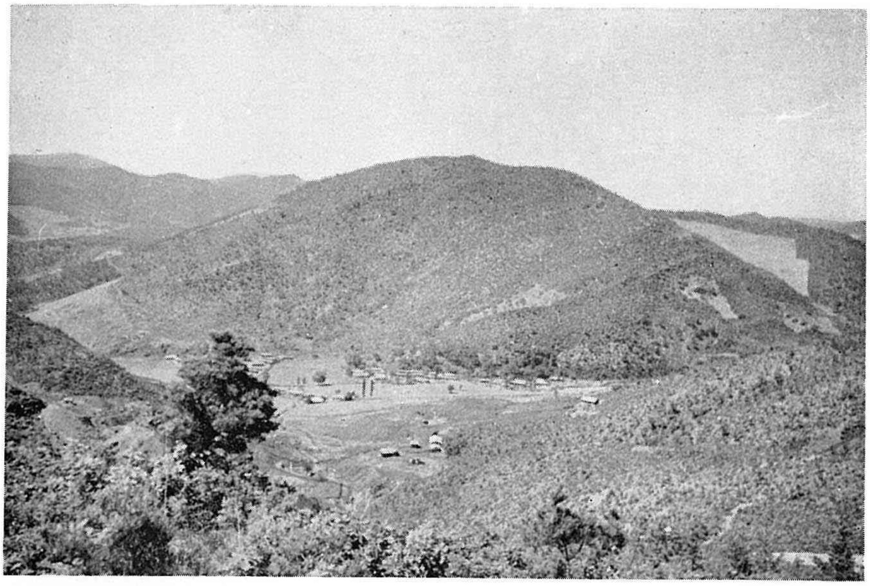


Fig. 1 Tokusan thrust at the type locality seen from south. Notice the overturned folding above the thrust plane. TT: Tokusan thrust, TsT: Tokusan subordinate thrust, BL: Ordovician Bantatsu Series, AS: Alnemi shale (basal Kôten), Kt: Kôten Series, UJ: Upper Jidô Series, T: Tokusan colliery.

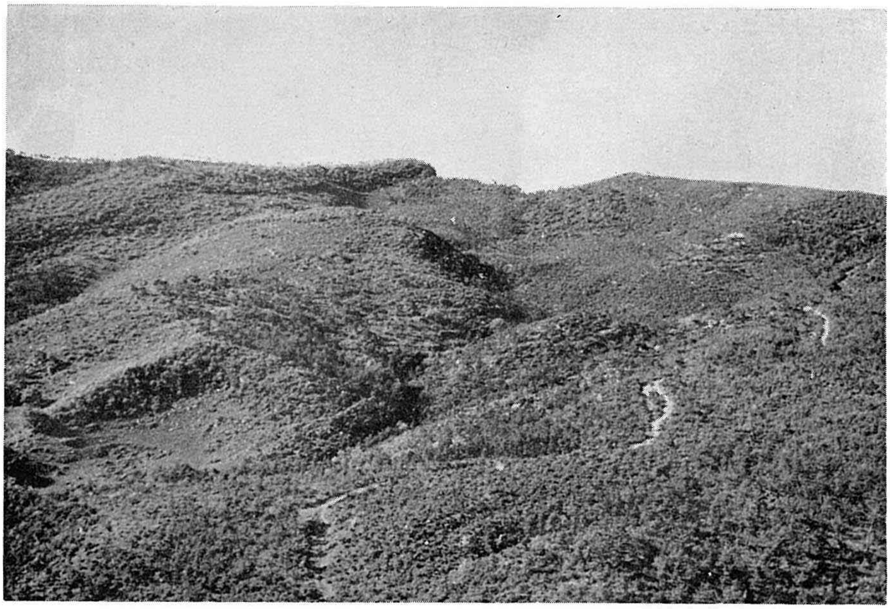
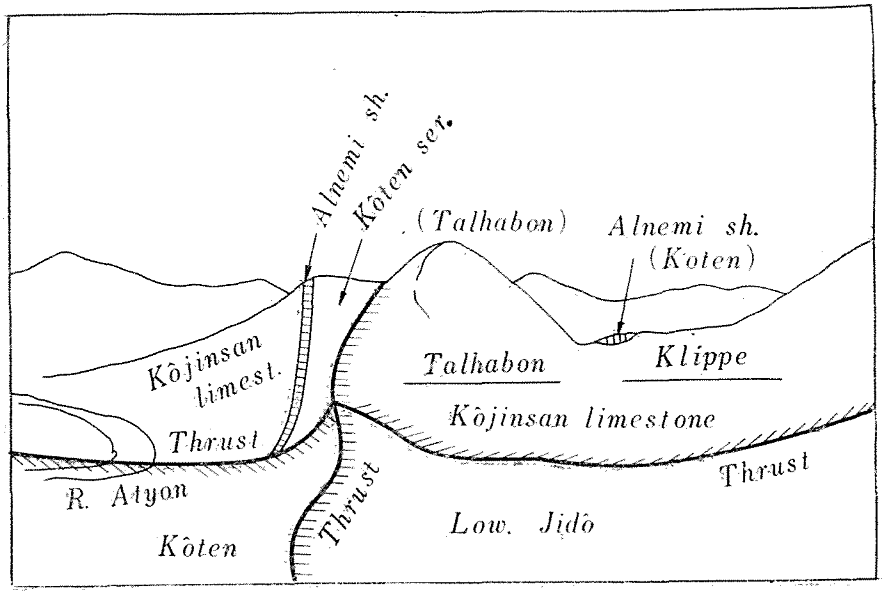


Fig. 2 Tokusan thrust south of the Tokusan colliery, between Tokusan and Munnaekol (Bunnaidô). TT: Tokusan thrust, TsT: Tokusan subordinate thrust, BL: Ordovician Bantatsu Series, UJ: Upper Jidô Series, Kb: Kôbôsan Series.


Alnemi sh.
Kôten ser.
(Talhabon)
Alnemi sh.
(Koten)
Kôjinsan limest.
Talhabon
Klippe
Kôjinsan limestone
Thrust
R. Atyon
Thrust
Thrust
Low. Jidô
Kôten

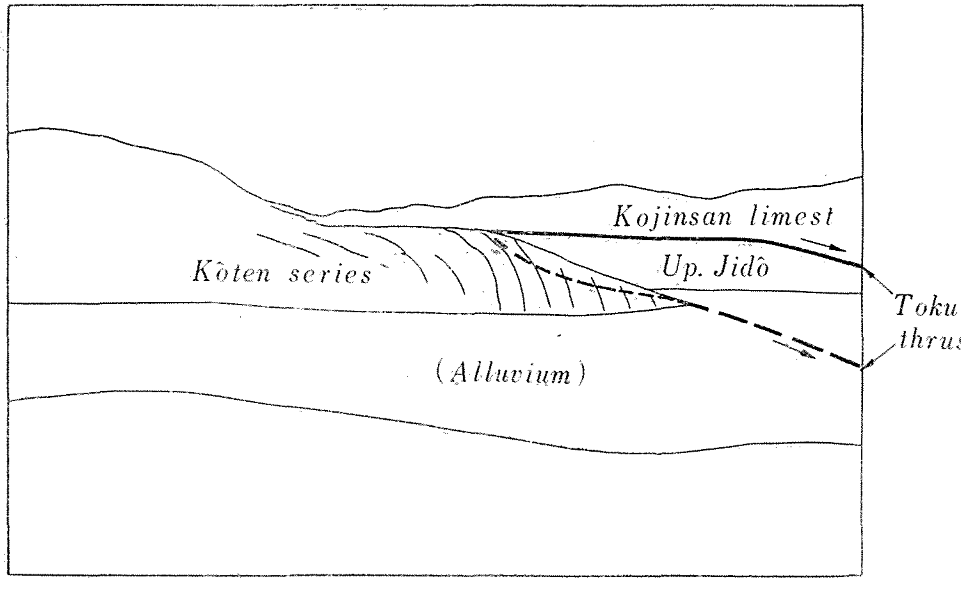

Kojinsan limest
Kôten series
Up. Jidô
(Alluvium)

Fig. 1 Talhabon (Takkabô) *Klippe*, east of Mt. Fuklyongsan north of Samtung, seen from a hill north of Mulpikol.

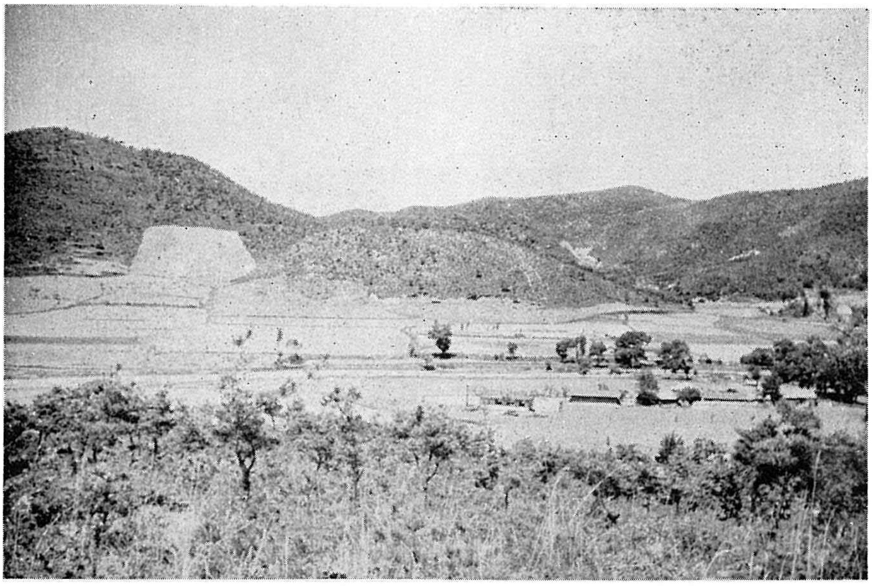
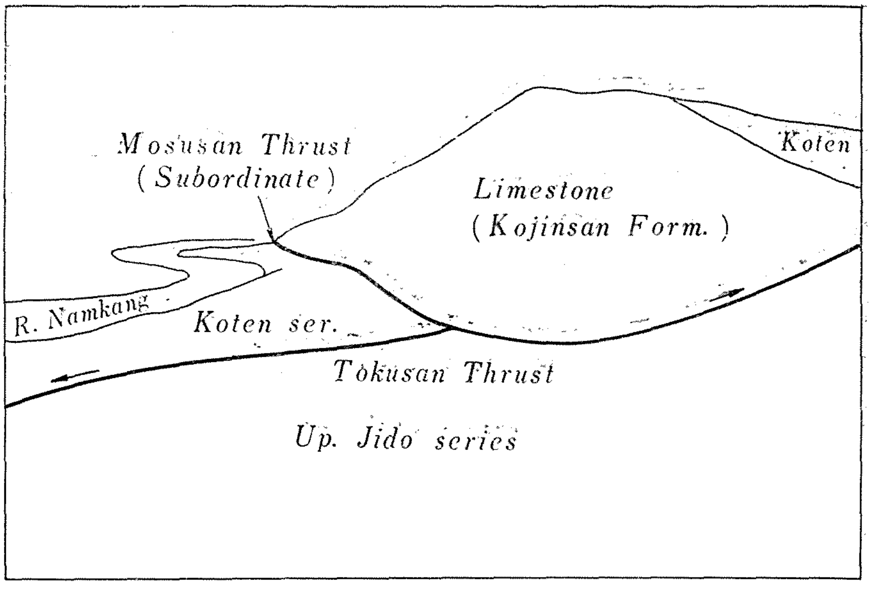


Fig. 2 *Fenster* of the Upper Jidô, encircled by the overlying Ordovician Kôjinsan formation (Bantatsu Series) and the Carboniferous Kôten Series, at Naedon (Naidô), west of Sonkolini (Shôgairi).


Mosusan Thrust
(Subordinate)
Limestone
(Kojinsan Form.)
Koten
R. Namkang
Koten ser.
Tokusan Thrust
Up. Jido series

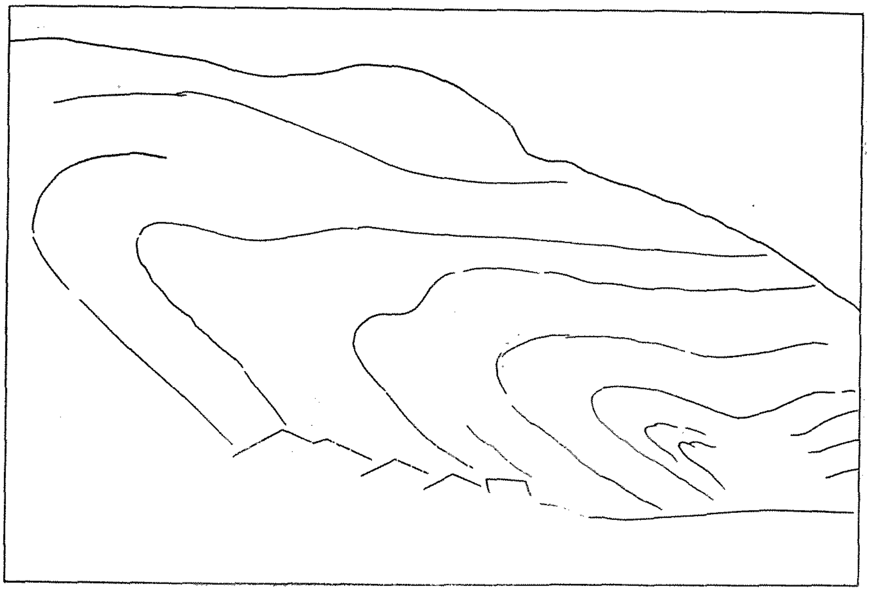


Fig. 1 Tokusan thrust at Mosusan, south of Toksan, seen from northeast.

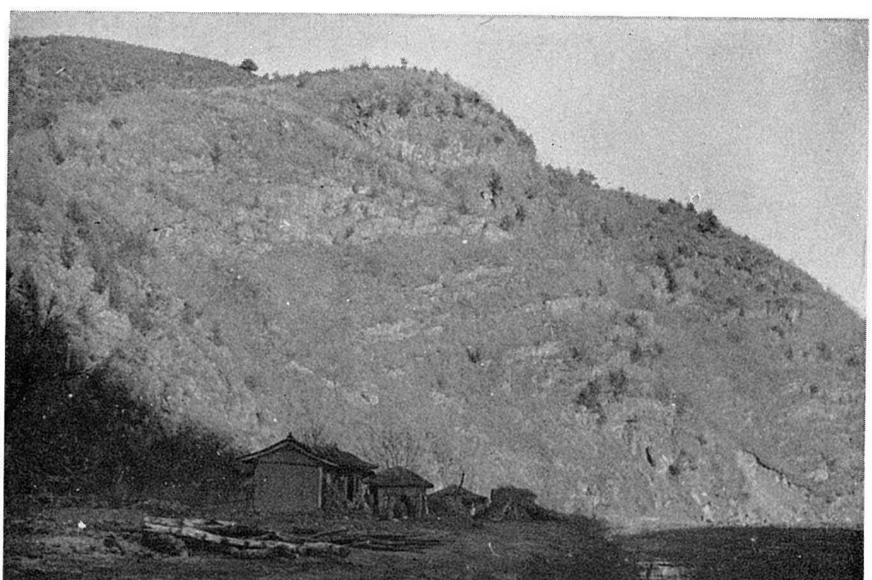
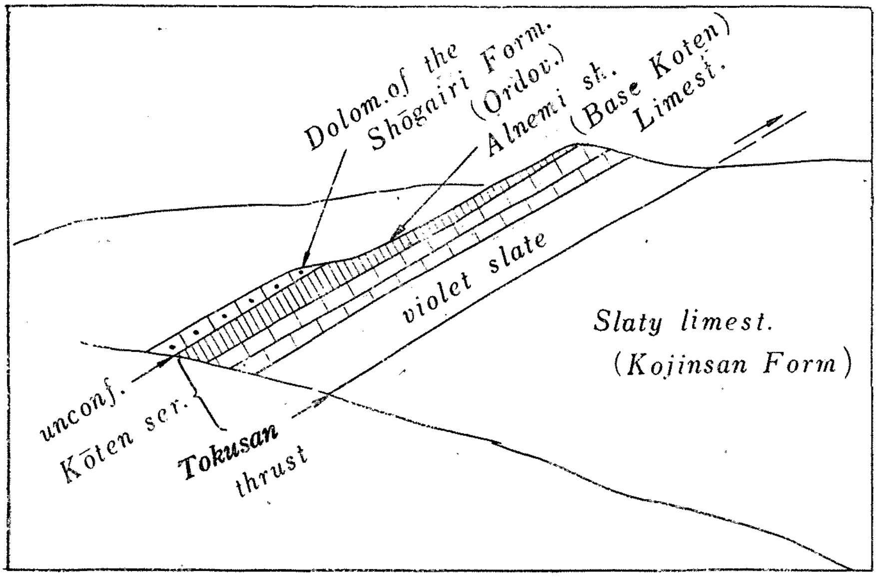


Fig. 2 Overturned folding in the Kôten Series of the Tokusan Nappe, at Mulpanakan (Suitandô), west of Fuklyongsan (Kokureisan).


Dolom. of the
Shōgairi Form.
(Ordov.)
Alnemi st.
(Base Koten)
Limest.
violet slate
Slaty limest.
(Kojinsan Form)
unconf.
Kōten ser.
Tokusan
thrust

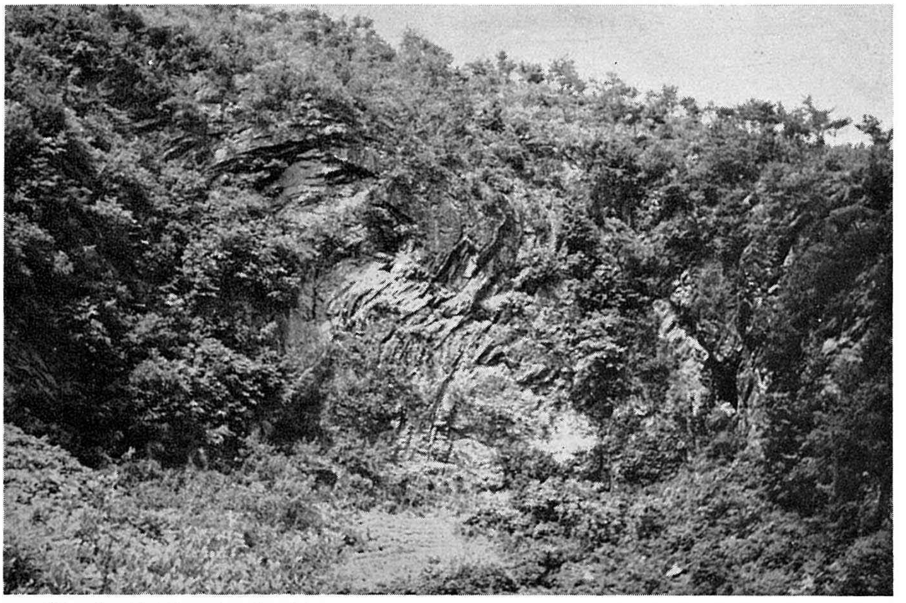
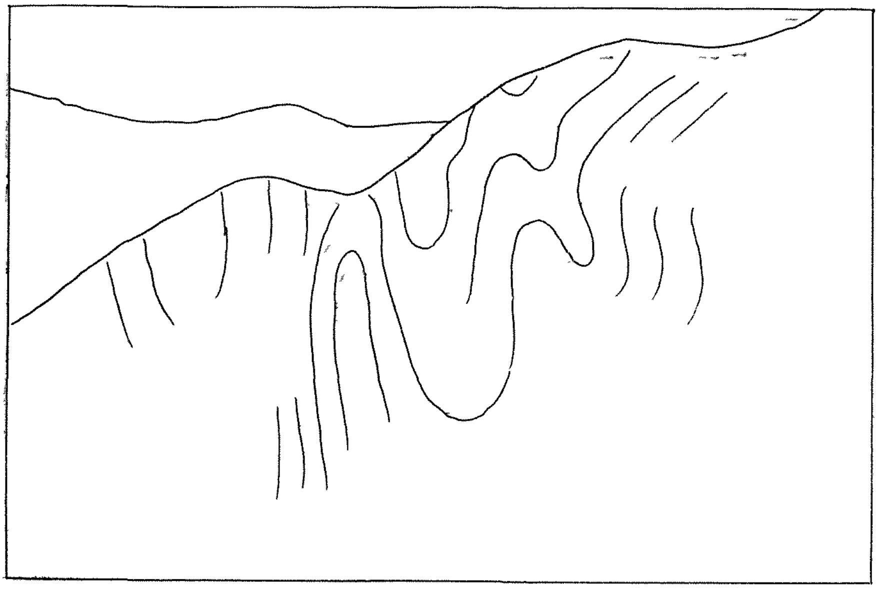
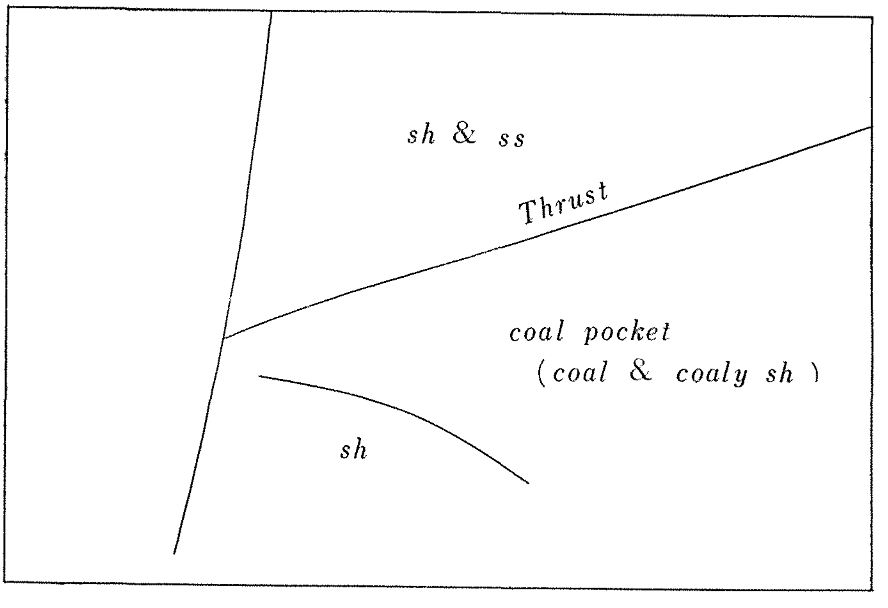


Fig. 1 Folding in the Kôjinsan limestome (Bantatsu Series) of the Tyawelyongni (Saireiri) *Halbklippe* of the Tokusan Nappe, at Tyawelyongni.

Fig. 2 Tokusan thrust immediately northwest of Samtung. Notice the stratigraphical succession of the strata above the thrust plane is reversed.




sh & ss
Thrust
coal pocket
(coal & coaly sh)
sh

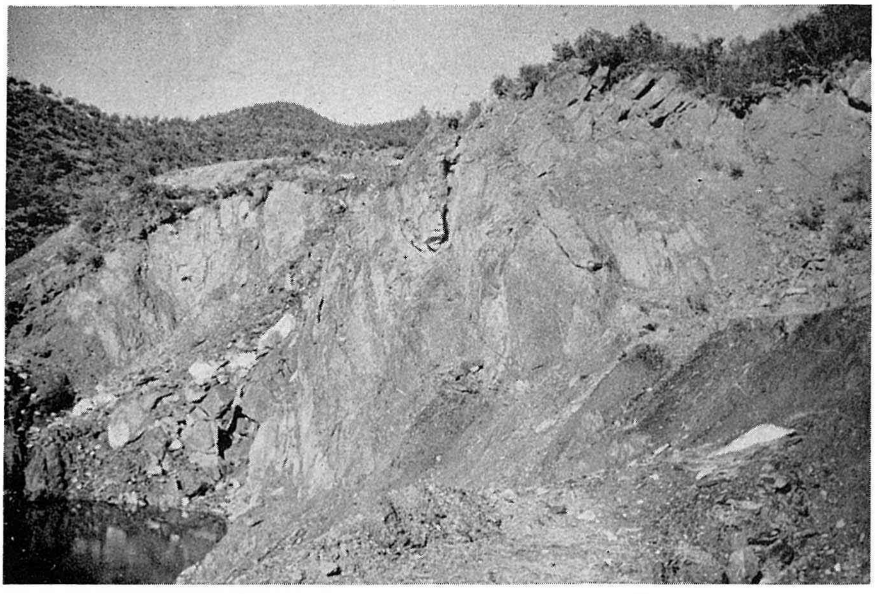


Fig. 1 Folding in the Jidô Series of the Samtung coal-bearing mass, just below the Tokusan thrust, at Munnaekol (Bunnaidô), south of Toksan.

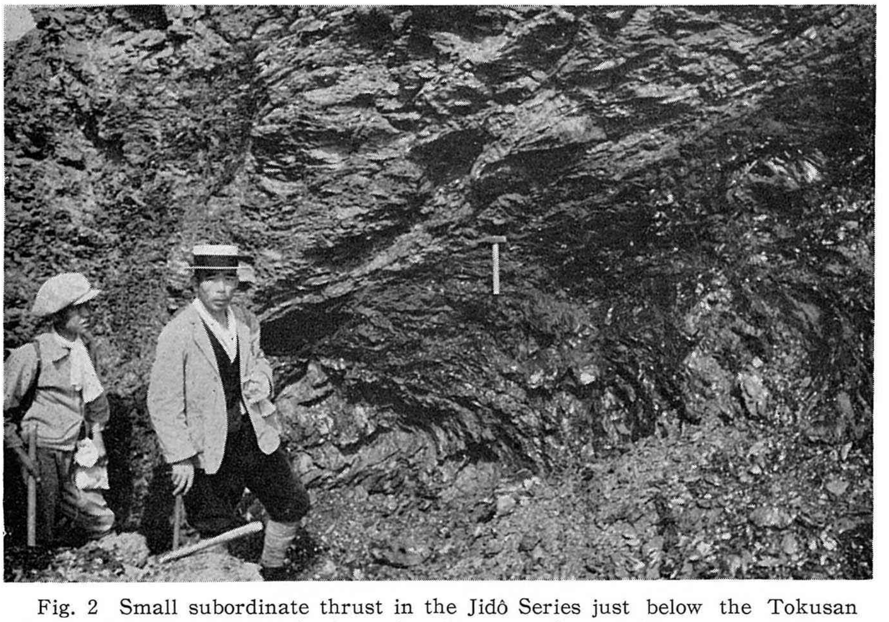
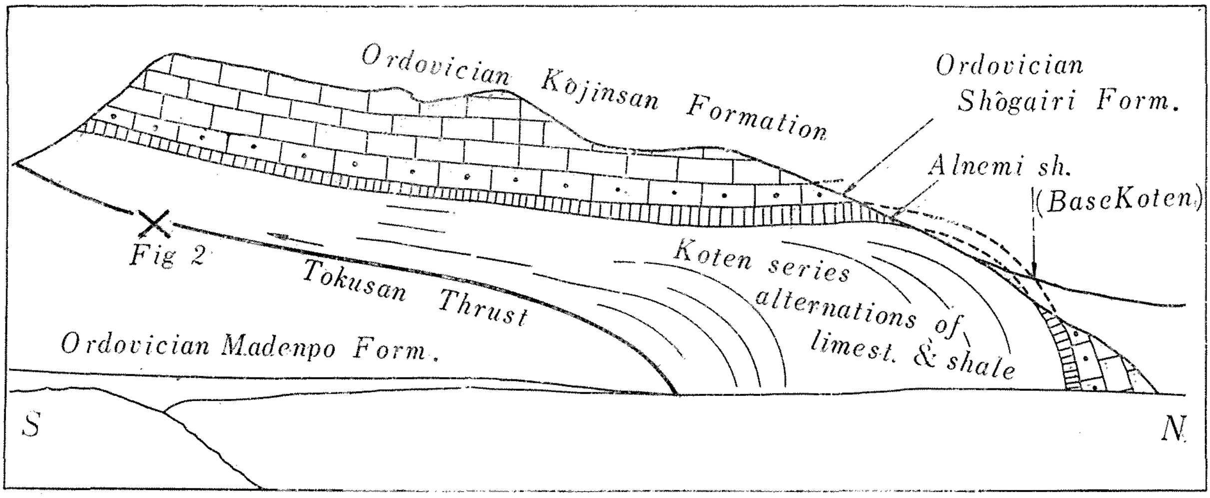
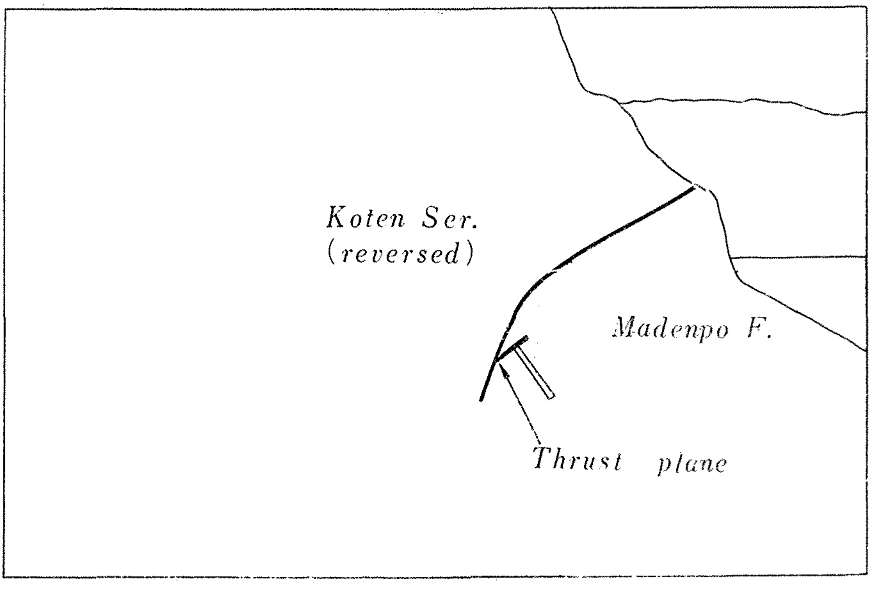
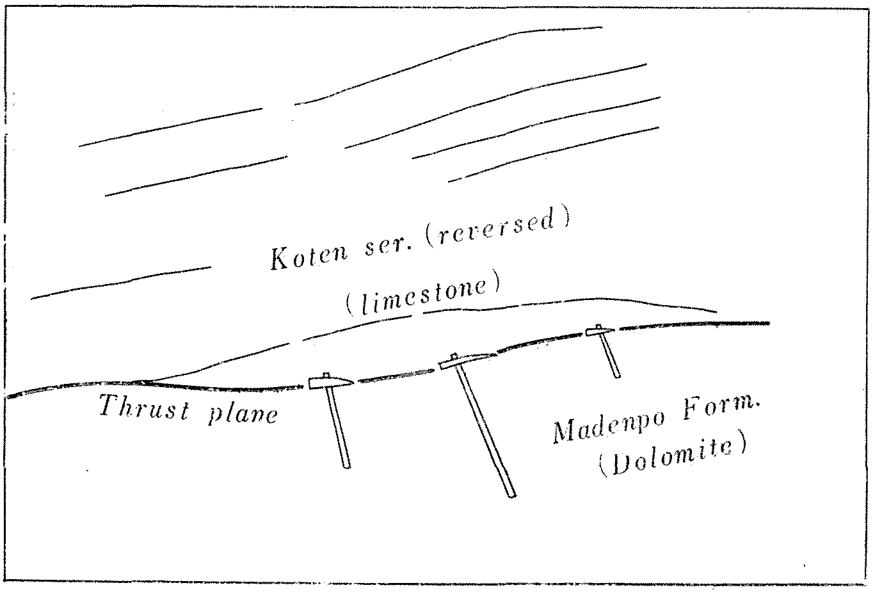
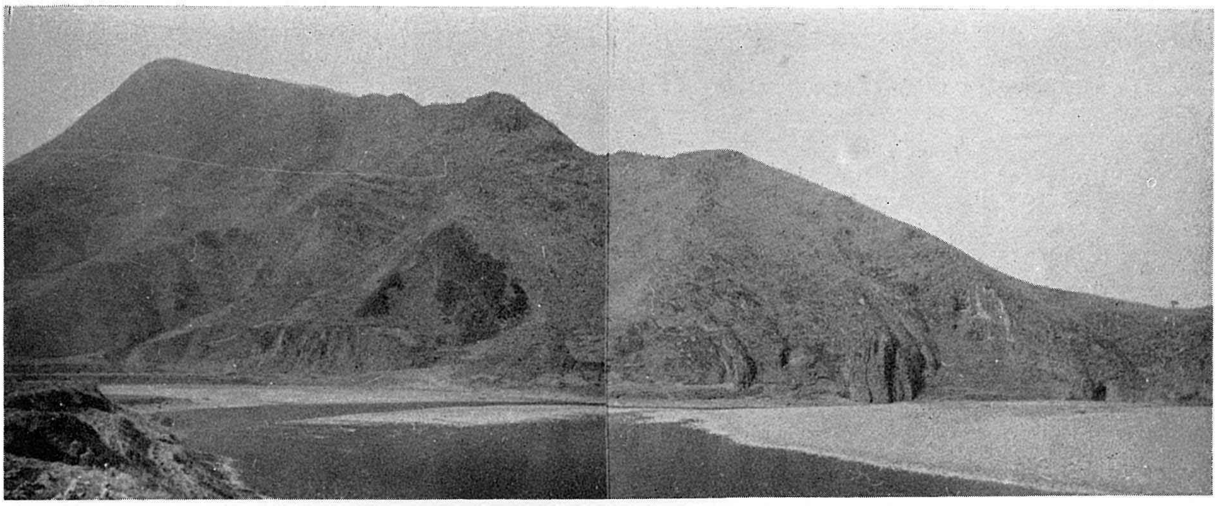


Fig. 2 Small subordinate thrust in the Jidô Series just below the Tokusan thrust plane, at Kokurei (Fuklyong) colliery, north of Fuklyongsan. Notice a coal pocket is related to a small thrust.


Ordovician Kôjinsan Formation
Ordovician
Shôgairi Form.
Alnemi sh.
(BaseKoten)
Fig 2
Tokusan Thrust
Koten series
alternations of
limest. & shale
Ordovician Madenpo Form.
S
N


Koten Ser.
(reversed)
Madenpo F.
Thrust plane


Koten ser. (reversed)
(limestone)
Thrust plane
Madenpo Form.
(Dolomite)



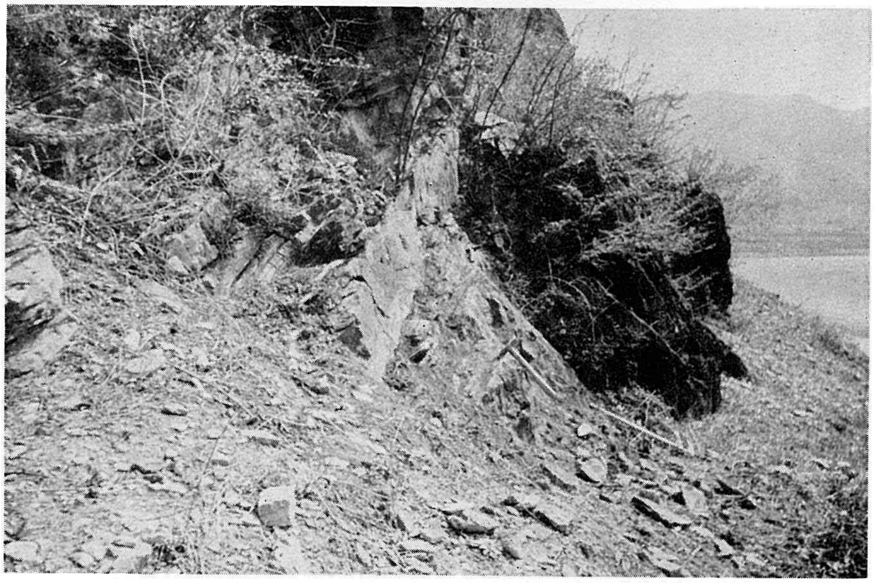
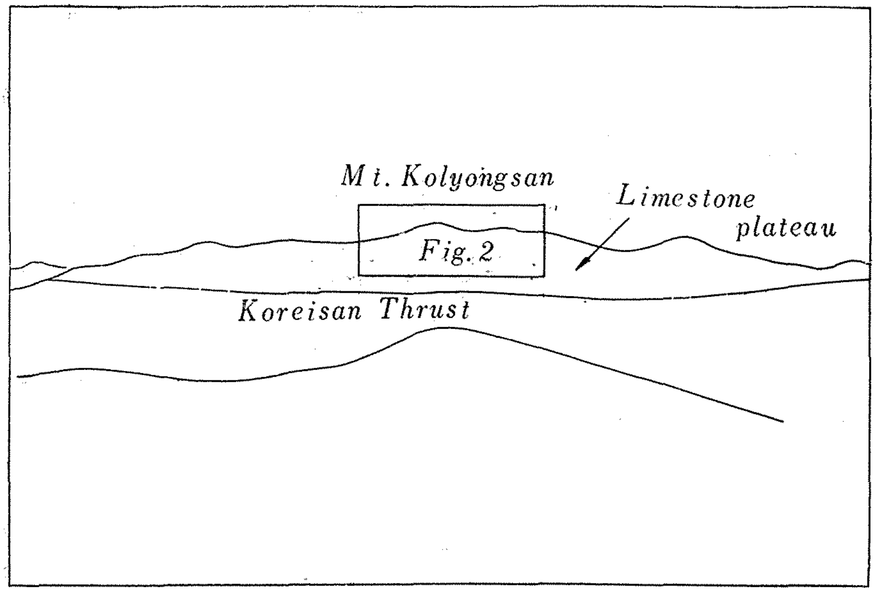


Fig. 1 Tokusan thrust at the eastern scarp of Mt. Songtongamsan (Jôtôgansan), SW of Samtung. Notice the southward thrusting and the overturned folding suggested by tracing the basal Kôten Alnemi shale.

Fig. 2 An outcrop of the Tokusan thrust at the place marked with × on the above picture (Fig. 1).

Fig. 3 An outcrop of the Tokusan thrust in a cliff, (opposite to Fig. 1) east of the junction of R. Namkang and R. Pemi.


Mt. Kolyongsan
Limestone plateau
Fig. 2
Koreisan Thrust

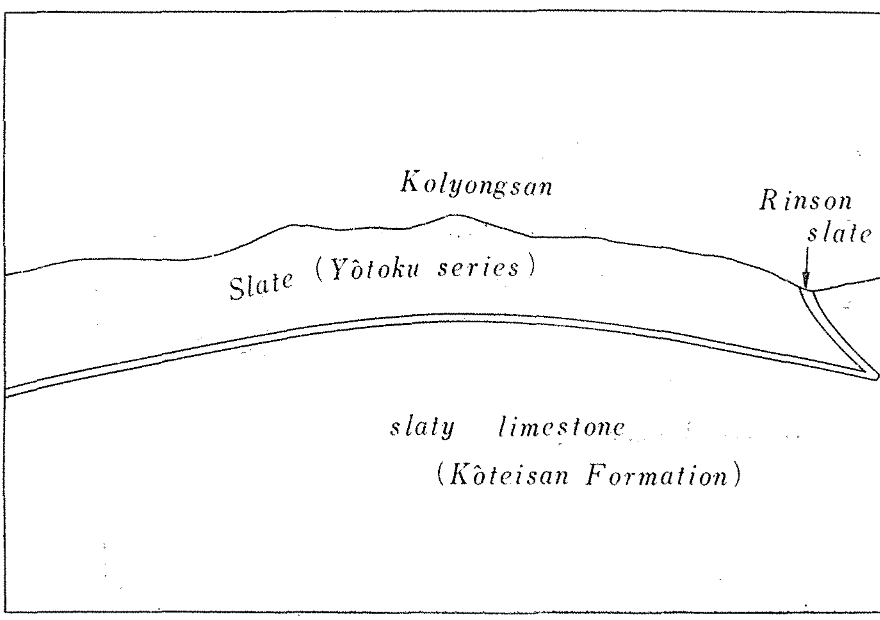

Kolyongsan
Rinson slate
Slate (Yôtoku series)
slaty limestone
(Kôteisan Formation)

Fig. 1 Distant view of Mt. Kolyongsan (Kôreisan) from north, showing the distribution of the Kôreisan thrust, and the limestone plateau. A river in the center is R. Namkang (Nankô).

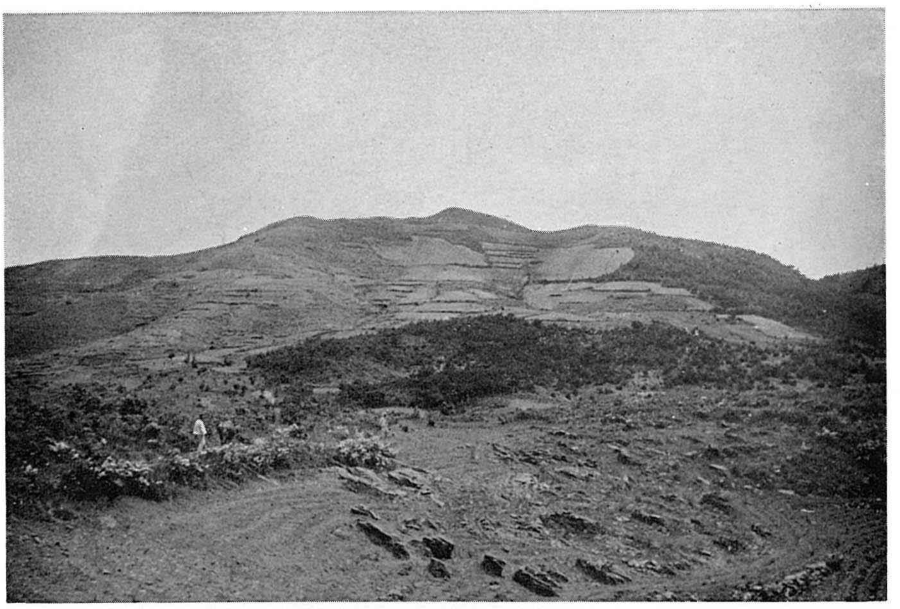
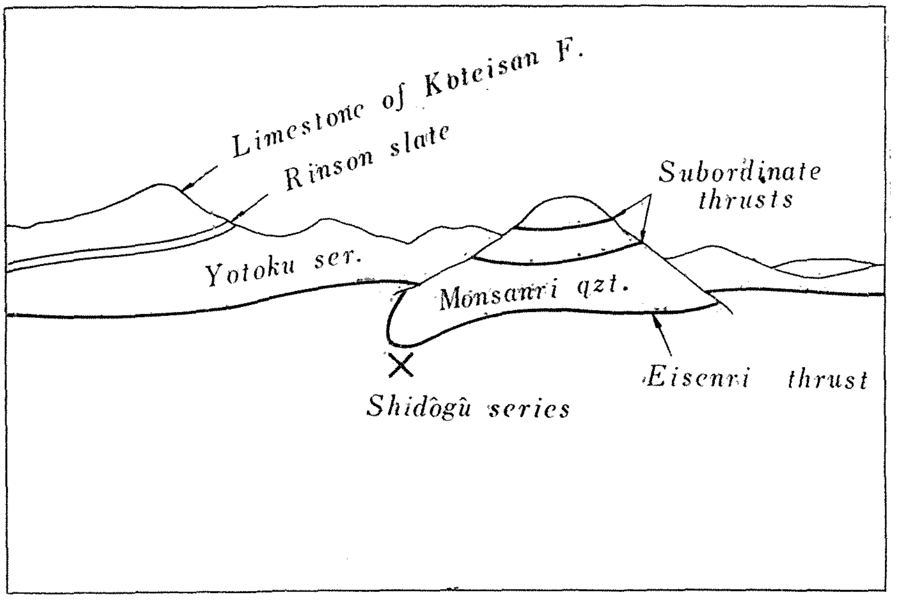
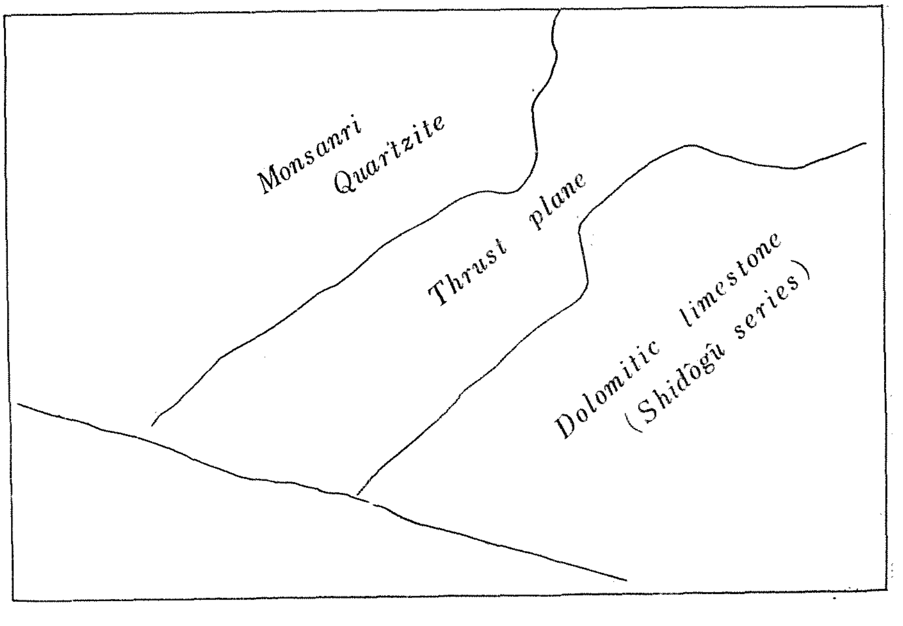


Fig. 2 Near view of Mt. Kolyongsan, marked in the center of the above figure, showing the morphological difference between the Mt. Kolyongsan consisting of slates of the Yôtoku Series and the limestone plateau in front of it.



Limestone of Koteisan F.
Rinson slate
Subordinate thrusts
Yotoku ser.
Monsanri qzt.
Shidôgû series
Eisenri thrust



Monsanri Quartzite
Thrust plane
Dolomitic limestone (Shidôgû series)

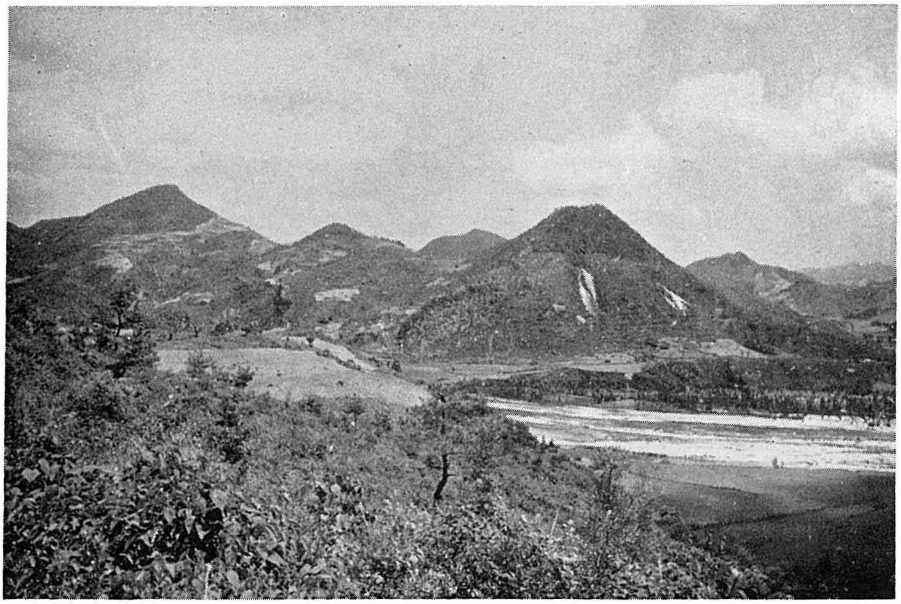


Fig. 1 Eisenri thrust of the eastern outside area of the coal field, at Yongchyonli (Eisenri), seen from south.

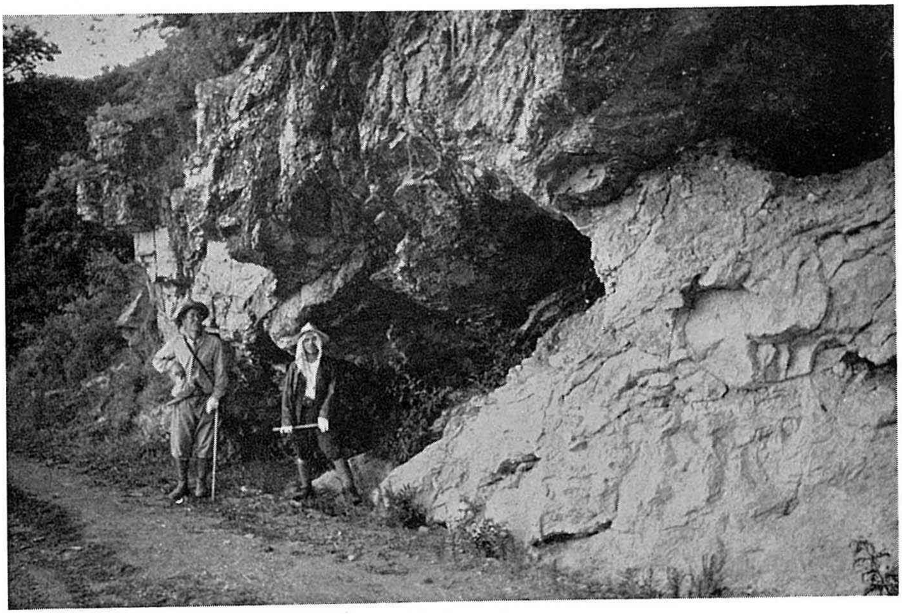
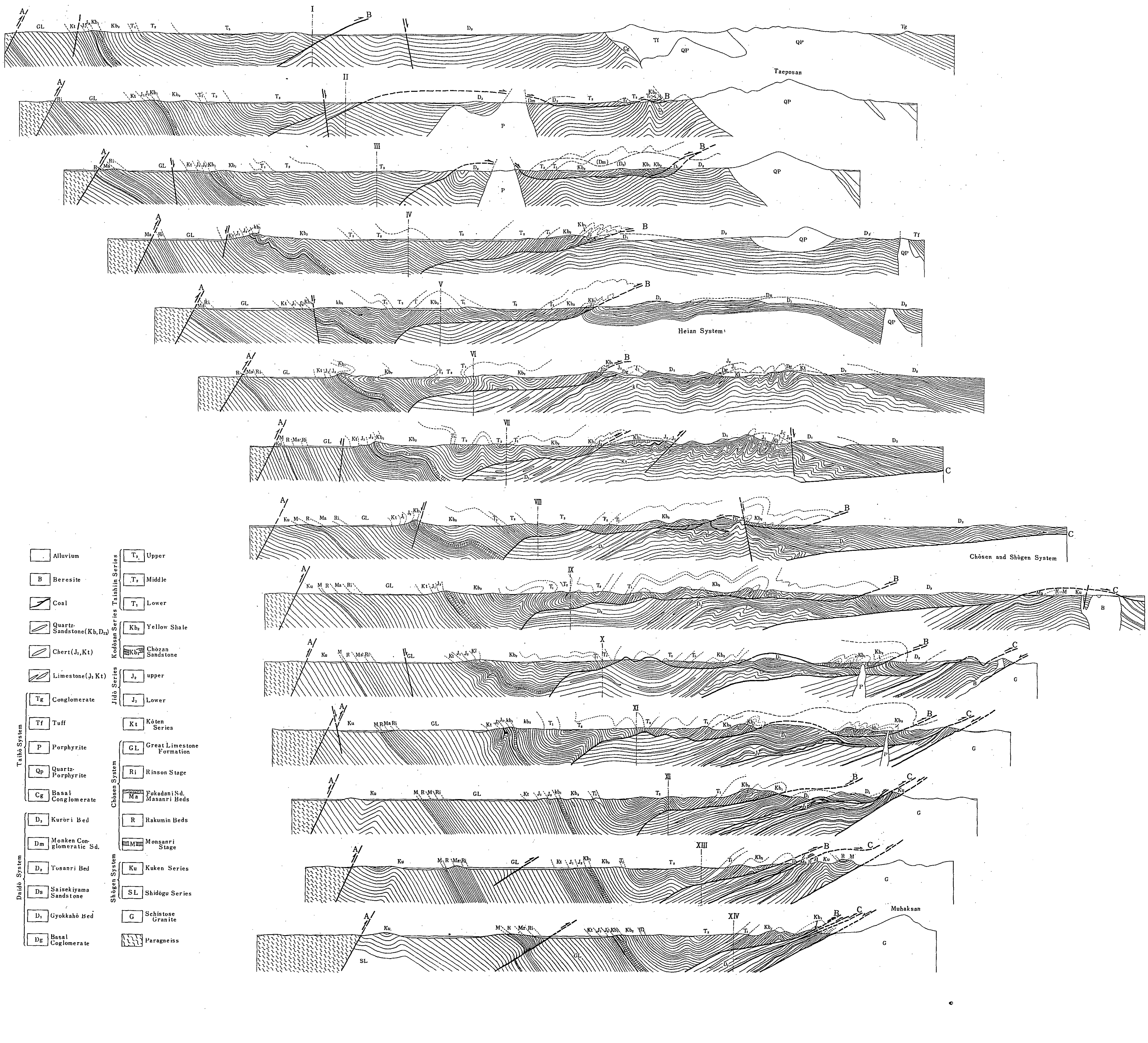
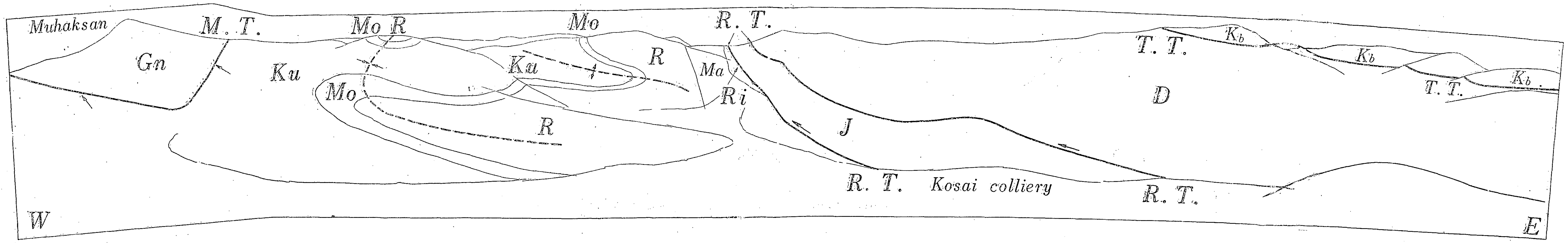
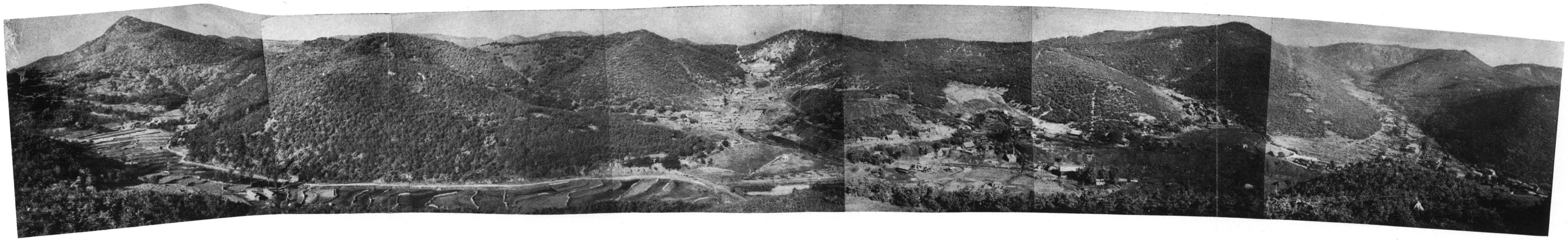


Fig. 2 An outcrop of the Eisenri thrust at Yongchyonli (marked with × on the above picture.

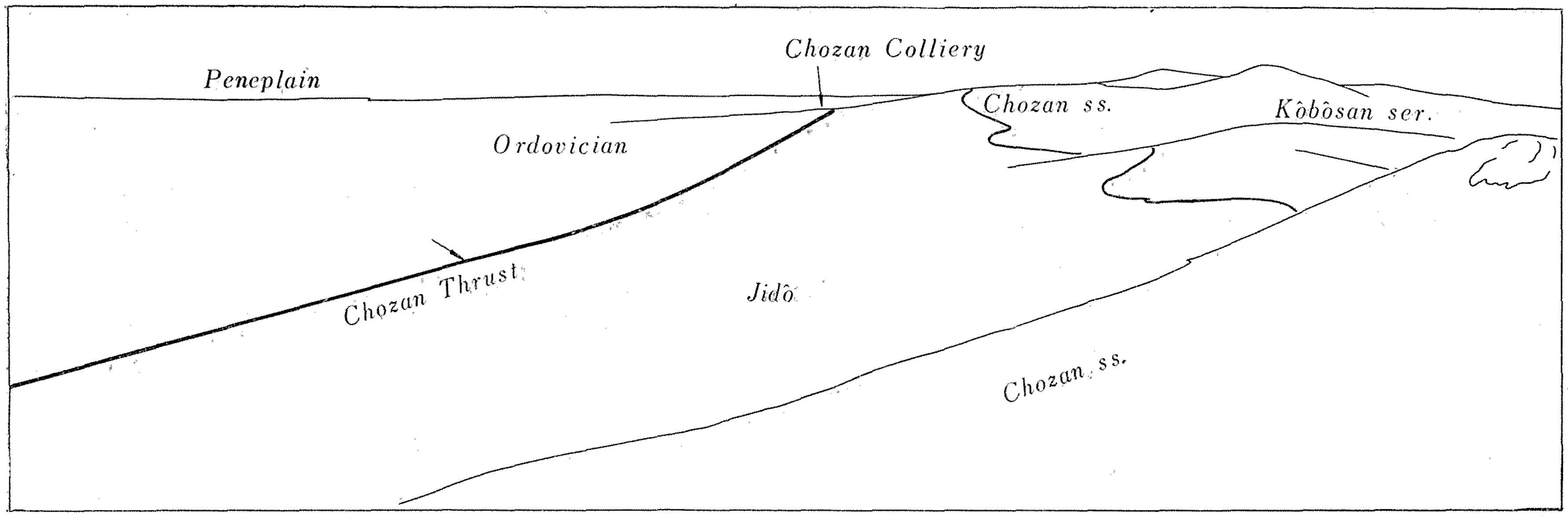
Geologic Profiles of the Western Part of the Phyongyang Coal Field




Muhaksan
M. T.
Mo R
Mo
R. T.
Gn
Ku
Ka
R
Ma
Mo
Ri
R
J
T. T.
Kb
Kb
T. T.
Kb
D
R. T.
Kosai colliery
R. T.
W
E

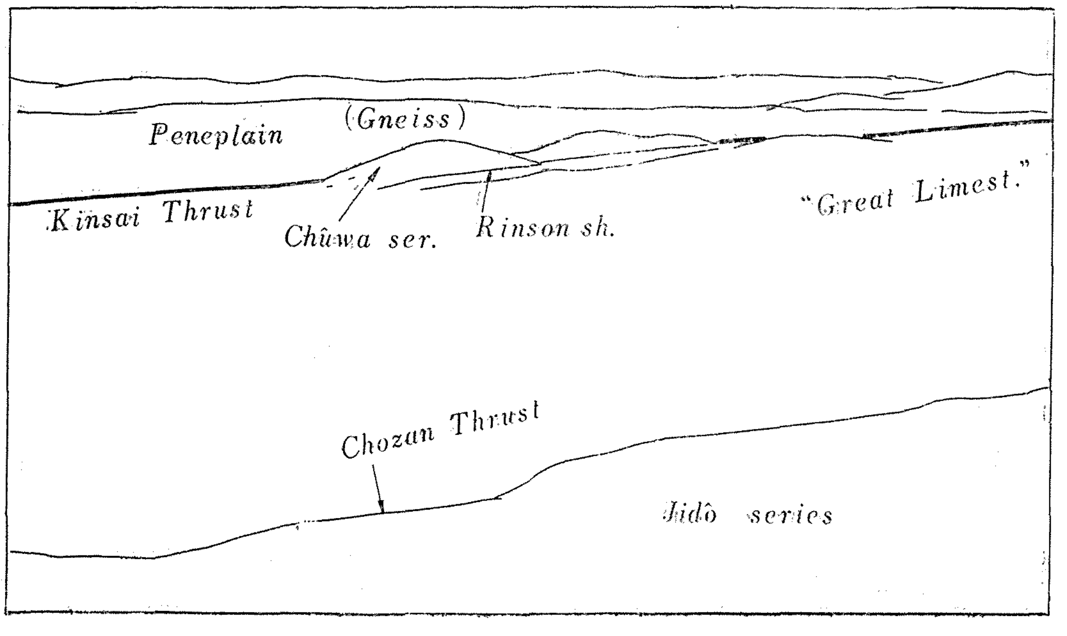


The Kôsai (Kangso) colliery (A Pit) near the western margin of the Phyongyang Coal Field, showing the situation of the tectonic arrangements.
Gn: Mukakusan granite, Ku: Kuken Series (Shôgen System), Mo: Monsanri quarzite, R: Rakumin bed (Chûwa Series), Ma: Masanri bed (Chûwa Series), Ri: Rinson shale, J: Lower and Upper Jidô Series, Kb: Kôbôsan Series, D: Daidô System, M.T.: Mukakusan thrust, R.T: Ryûsei thrust, T.T: Taihô thrust.



Chozan Colliery
Peneplain
Chozan ss.
Kôbôsan ser.
Ordovician
Chozan Thrust
Jidô
Chozan ss.

View of a part of the Tyangsan (Chôzan) hill ridge (right) and the Syunhoakang (Junwakô) peneplain (left). Foldings of the Chôzan sandstone (basal sandstone) of the Kôbôsan Series, on the top of the ridge, produce echelon type arrangement of the hills.


Peneplain
(Gneiss)
Kinsai Thrust
Chûwa ser.
Rinson sh.
"Great Limest."
Chozan Thrust
Jidô series

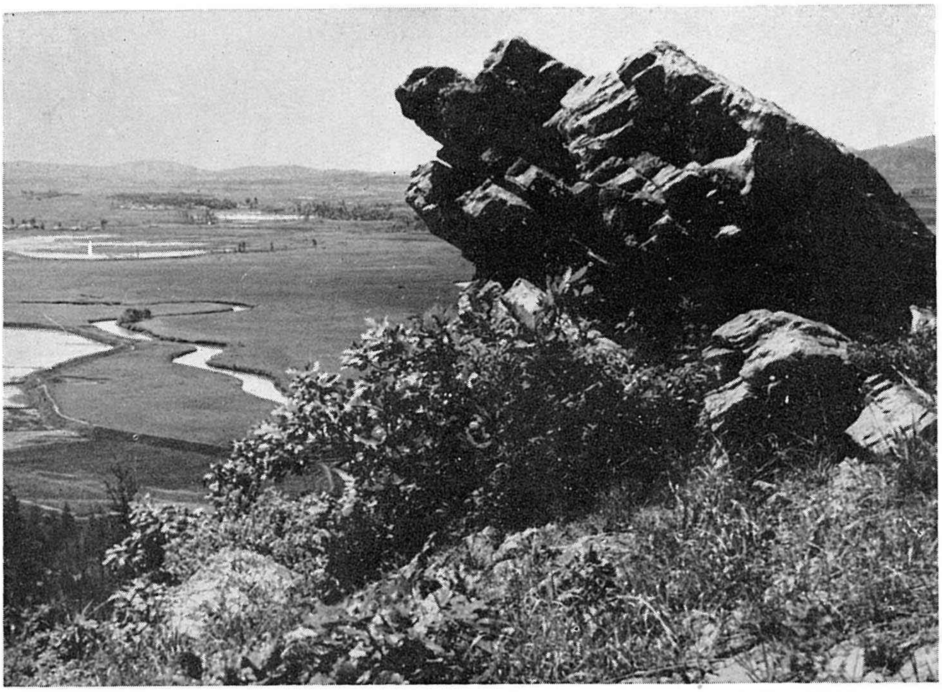


Fig. 1 An outcrop of the Chôzan sandstone (basal part of the Kôbôsan Series) on the top of the Chôzan (Tyangsan) hill range.

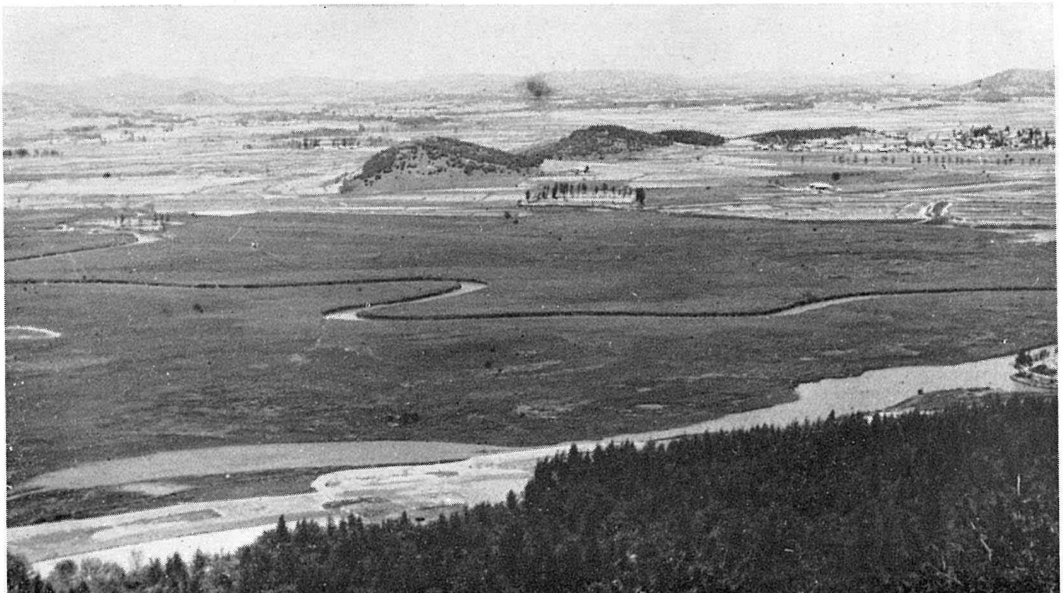
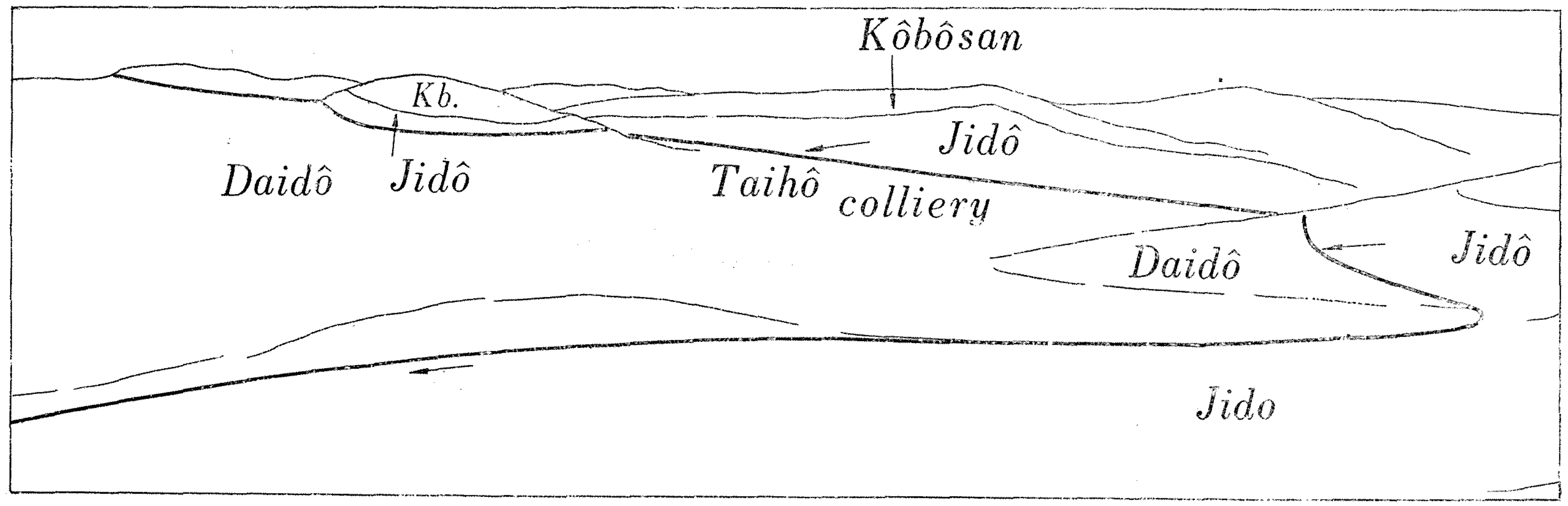
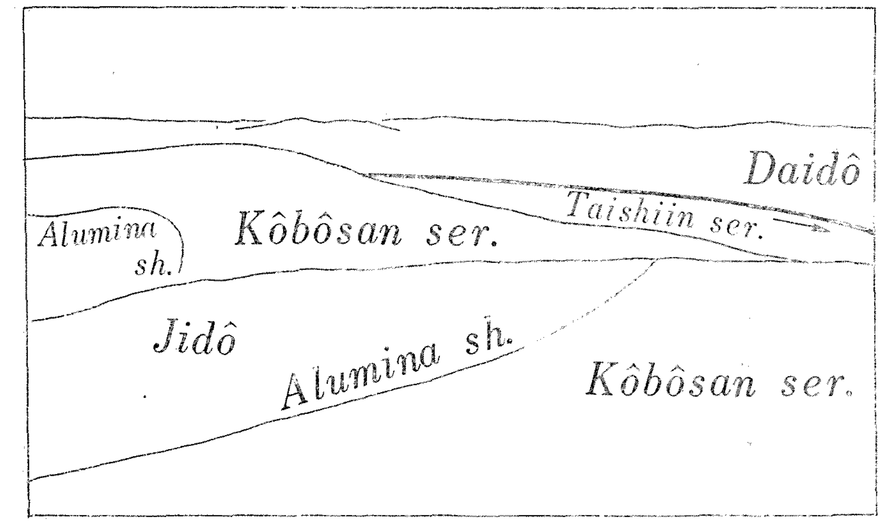
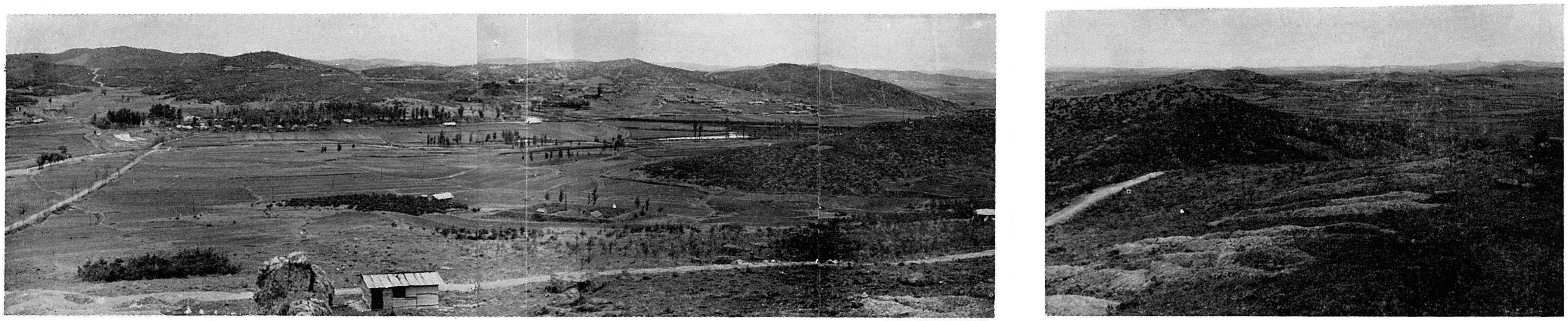


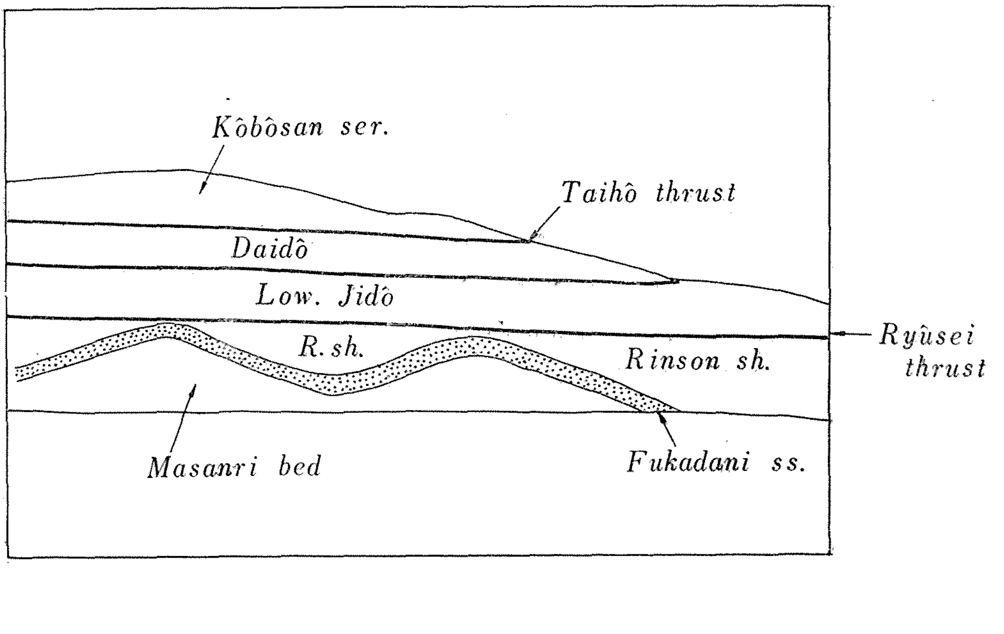
Fig. 2 Junwakô (Syunhoakang) peneplain seen from a top of the Tyangsan (Chôzan) hills. The peneplain is geologically made up of the gneissose rocks of the Keirin System and the Cambro-Ordovician "Great Limestone Formations", whereas a monadonocks seen in the center of the figure consist of the Cambrian shales of the Chûwa Series.


Kôbôsan
Kb.
Jidô
Daidô
Jidô
Taihô
colliery
Daidô
Jidô
Jido


Daidô
Taishiin ser.
Alumina sh.
Kôbôsan ser.
Jidô
Alumina sh.
Kôbôsan ser.



View of the eastern part of the Taihô (Taepo) colliery from a small hill (Chigansan), showing a complicated distribution of the Taihô thrust.



Kôbôsan ser.
Taihô thrust
Daidô
Low. Jidô
R. sh.
Rinson sh.
Ryûsei thrust
Masanri bed
Fukadani ss.

Fig. 1 An outcrop of the injection gneiss in the Keirin System, near Muntong, Sangnong-myon, western outside area of the coal field.

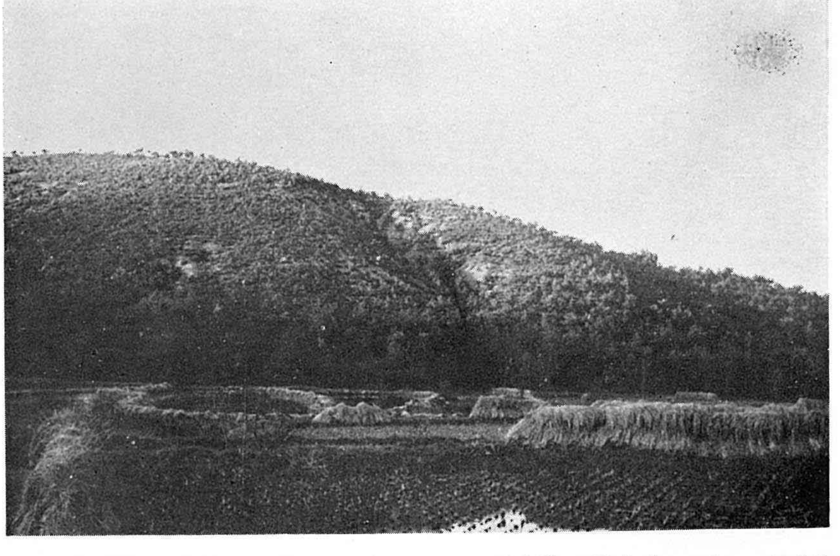
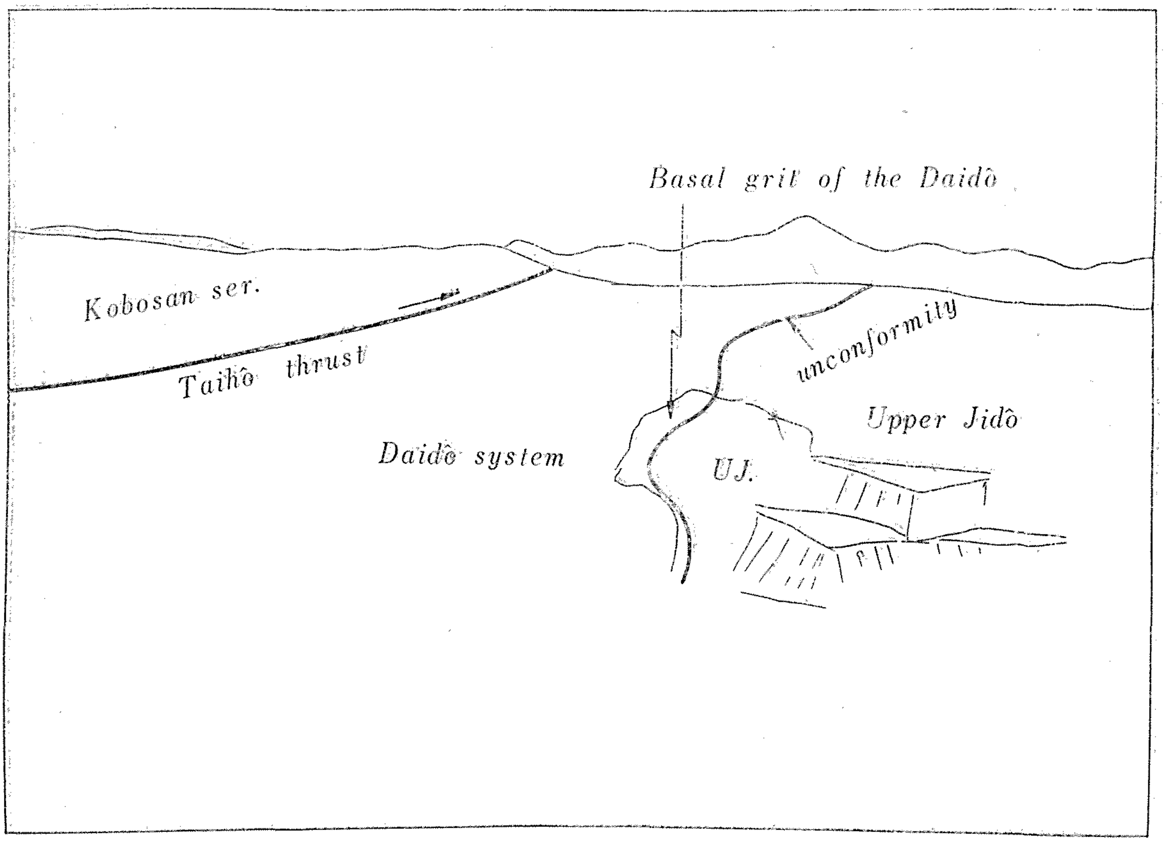
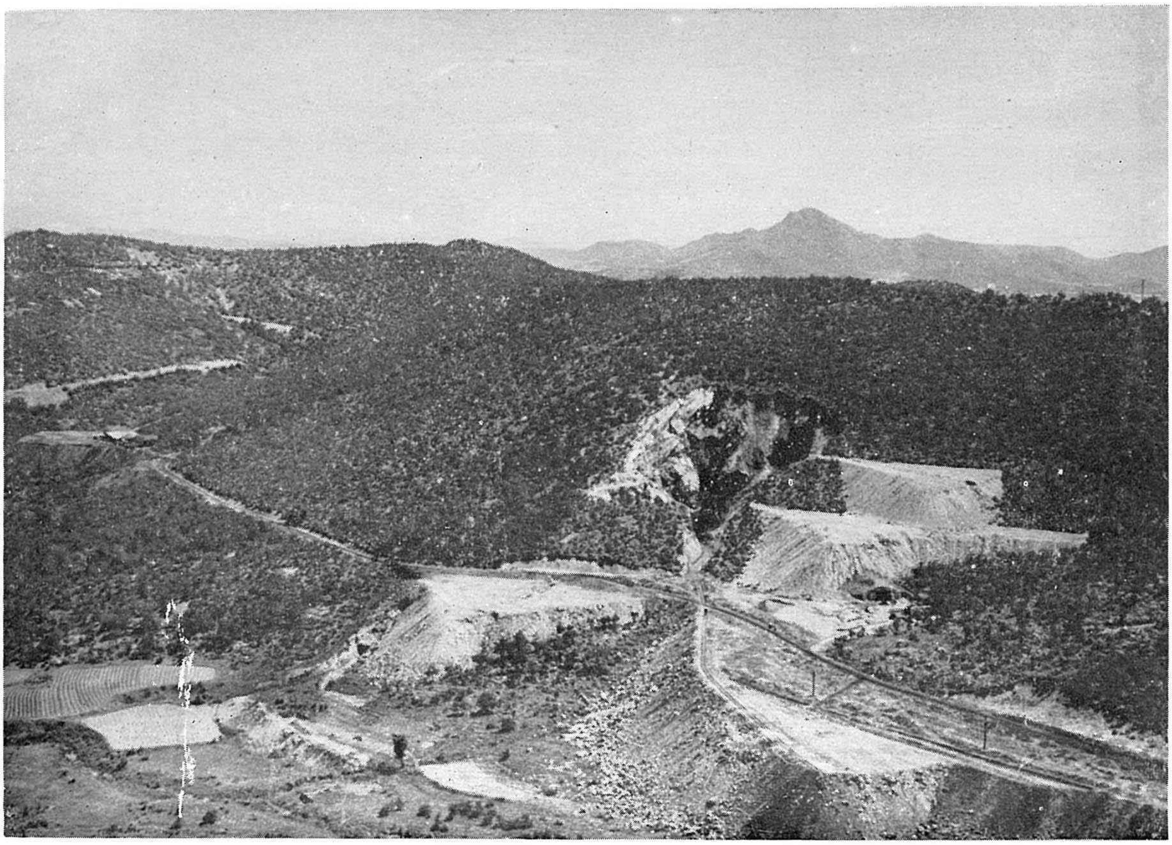


Fig. 2 View of the southern flank of a small hill at Hakchyonni, west of the Kôsai colliery, showing the structural relations of the Kôbôsan Series, the Daidô, the Heian and the Chôsen Systems, bounded by closely situated three thrusts.


Basal grit of the Daidô
Kobosan ser.
Taihô thrust
unconformity
Upper Jidô
Daidô system
UJ.



View of the No. 4 pit of the Taihô (Taepo) colliery. Strongly folded Upper Jidô Series (right) are unconformably overlain by the basal member of the Daidô System (center) which is in turn overthrust (the Taihô thrust) by the Kôbôsan Series (left).

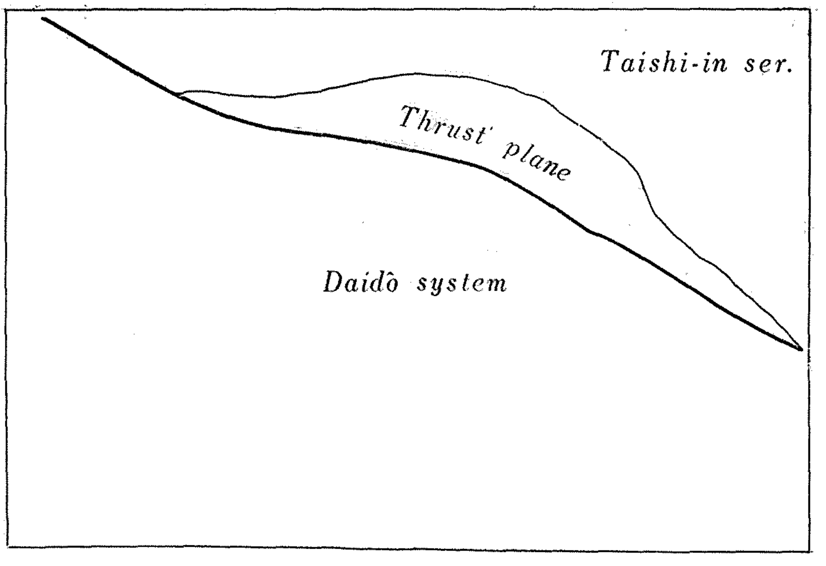
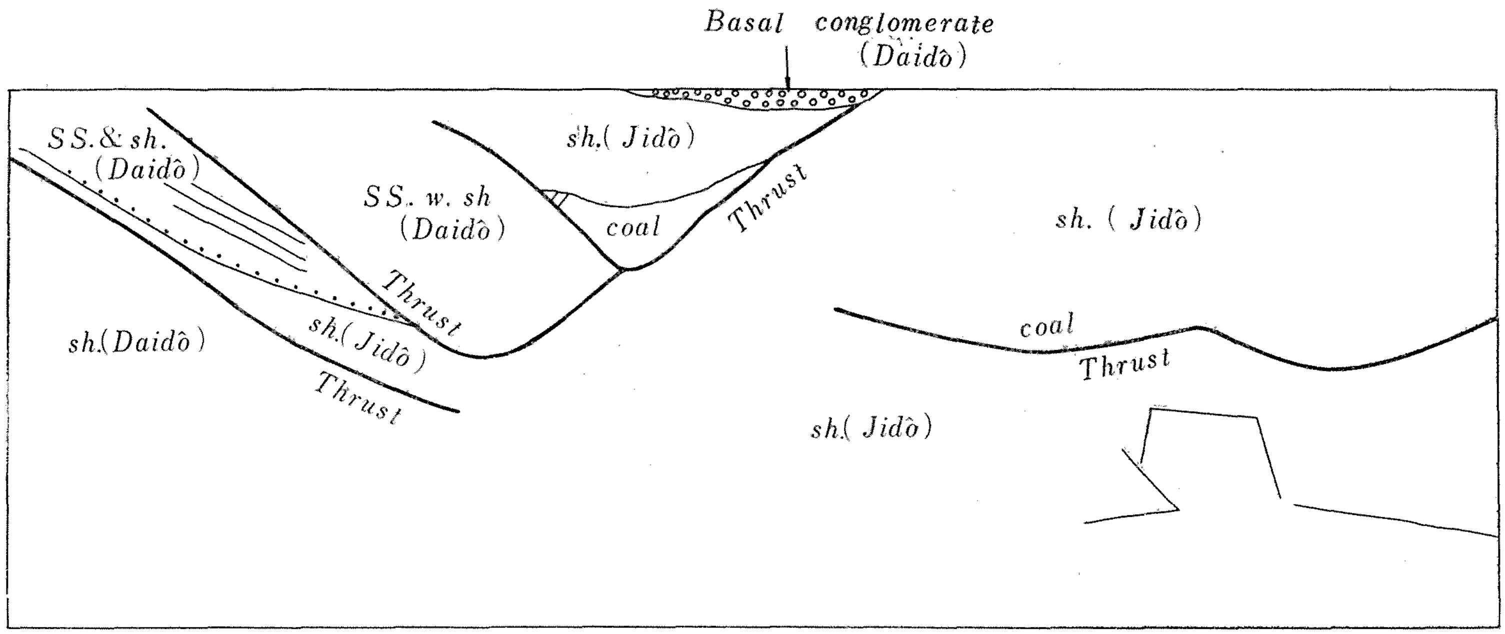
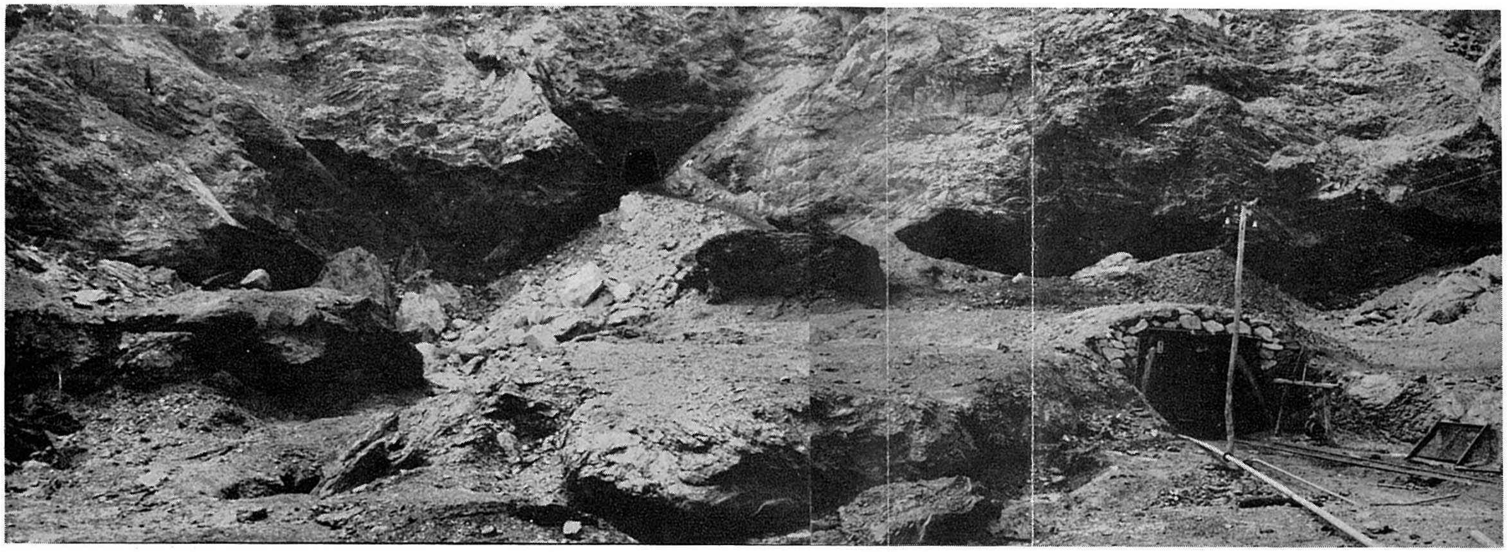

Taishi-in ser.
Thrust plane
Daidô system

Fig. 1 An outcrop of a strongly folded yellow shale of the Kôbôsan Series just above the Taihô thrust, near the Kôsai (Kangso) colliery.

Fig. 2 An exposure of the Taihô thrust plane, NE of Tokchanton, Taepo-myon.


Basal conglomerate
(Daidô)
SS.& sh.
(Daidô)
sh.(Jidô)
SS. w. sh
(Daidô)
coal
Thrust
sh. (Jidô)
Thrust
sh.(Daidô)
sh.(Jidô)
Thrust
coal
Thrust
sh.(Jidô)



Complicated network of small thrusts (subordinate to the Taihô thrust) in the Jidô and the basal part of the Daidô, exposed at Anjô-dô (Antyongton), Taihô colliery.

Plate XXIII

Plate XXIII

All figures in natural size, except otherwise stated.

Dadoxylon (*Cordaioxylon*) sp.

Fig. 1 Radial section, showing ray tissue.

Fig. 2 Radial section, showing bordered pits on tracheids.

Fig. 3 Radial section, showing uniseriate bordered pits.

Fig. 4 Transverse section, showing tracheids and ray tissue.

Sphenophyllum grandifolium sp. nov.

Fig. 5 Wide-spreading pairs of leaves and the short pending third pair.

Sphenophyllum kôbôense sp. nov.

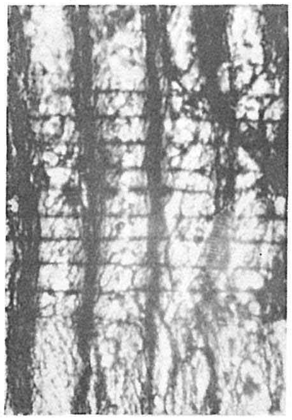
Fig. 6 Two verticils attach to the node. Shapes of leaves vary much and a small lower leaf is seen pending from node in the lowerright corner. The midnerve is prominent in large leaves.

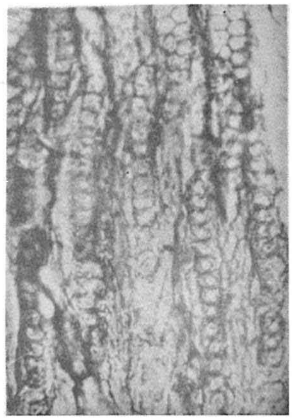
Fig. 7 Leaf fragments with strong midnerve.

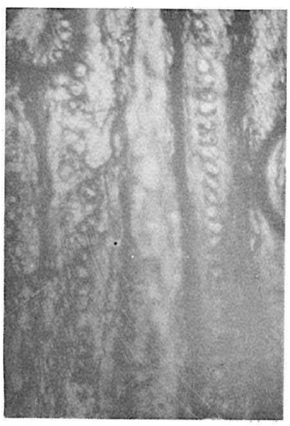
Fig. 8 Midnerve is less prominent but the minute splitting of veins are well represented. Locality: Taisei district

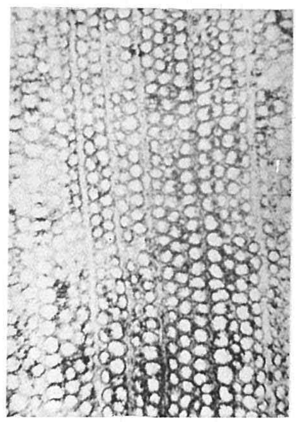

7

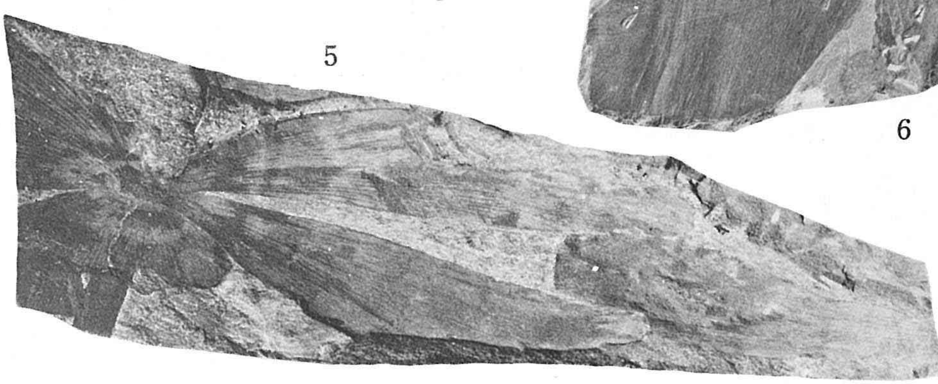

8


1


2


3


4


5

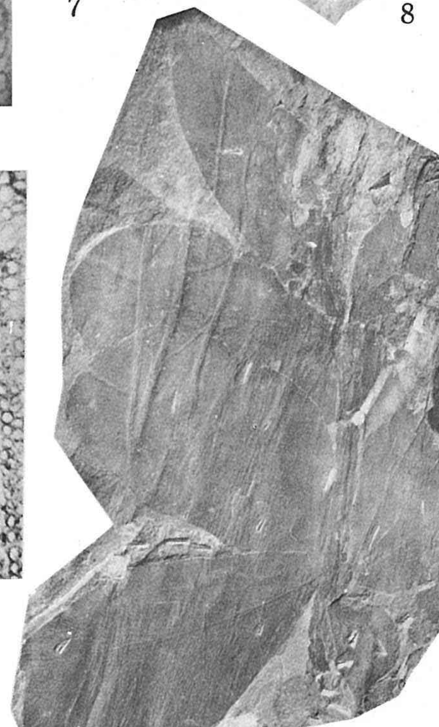

6

Plate XXIV

Plate XXIV

All figures in natural size, except otherwise stated.

Plagiozamites Nakamurai sp. nov.

Fig. 1 Large pinnae, overlapping obliquely the adjacent one suggest the semi-amplexicaul character. Tip of the lamina is truncated sharply and segmented. ca. 1/2 natural size

Fig. 2 Apical lobes and veins are well observed.

Sphenophyllum grandifolium sp. nov.

Fig. 3 A broken virticil.

Sphenophyllum kôbôense sp. nov.

Fig. 4 Long lanceolate leaf and orbicular distal half of a leaf. Very crowded veins and their course are clearly seen.

Fig. 5 A swollen node, having two fragments of leaves.

Pl. XXIV