# *Lung-yen Iron Ore Deposits and Stratigraphy of the Sinian System, North China*

Seiichi SHOJI and Tatsuo YAMASAKI

## I. Introduction

We had an opportunity to investigate in detail the Ta-tung region, a part of the Lung-yen iron ore field,[1] in North China for 6 months beginning in August, 1941. One of us (YAMASAKI) returned to Japan with detailed data and important specimens before completion of the survey. This paper covers these data, so inevitably the scope is rather narrow. SHOJI continued survey, and investigated the San-cha-kou region in Hsin-yao concession, and compared all the concessions and regions, but much of this data could not be taken back to Japan. This paper includes only a limited amount of this data.

The distribution, discovery, investigation, exploitation, geology, ore deposit, and ores were already described by TEGENGREN (1921, 1923) many years ago, and by M. WATANABE (1939) and KADOKURA (1939) recently, and many papers have been published on each region, so this paper will not be concerned with these aspects. We will discuss only the order of strata and the correlation of the Sinian system, involving ore beds, and will state the results of recently completed analysis and microscopy of ores.

We gratefully acknowledge the help of Dr. F. HOMMA and other senior geologists who directed us when they were in China, Professors K. KINOSHITA, T. TOMITA and M. NODA, who looked over this paper also kindly directed us, Mr. S. MATSUKUMA, and Mr. M. YAMAGUCHI who made microscopic examination of the ores, Mr. T. HARA, who analysed the ores for us, and Mr. Y. OKAMOTO, determined the minerals. We were especially guided by Dr. TOMITA while we were in Peking, and were given detailed instructions for correlation by Professor NODA.

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1) According to TEGENGREN (1921, 1923), J. G. ANDERSSON called this iron ore deposit the Hsuan-lung iron ores, but the name Lung-yen iron ores was taken from the name of the company after the ores began to be exploited. When the North China Development Co. started investigation, the names of concessions, such as Yen-tung-shan, Pang-chia-pu, and Hsin-yao, were used and every concession was divided into regions. The particulars are shown in Fig. 2. As for the name of places, see TEGENGREN, M. WATANABE (1939), and KADOKURA (1939) in the References.

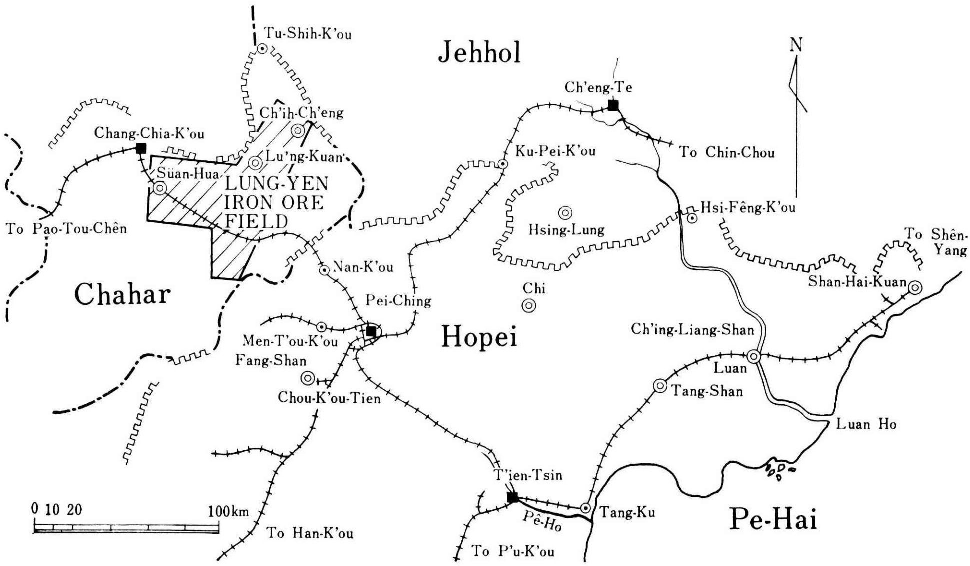


**Fig. 1.** Sketch map of Chahar, Hopei and Jehhol.

## II. Outline of Geology

The area treated in this paper is continuous to the Yen-tung-shan region, which was operated actively, extending across a wide valley. It extends for about 15 km from Tung-pao-sha in Hsuan-hua-hsien in the west to Tung-ke-yu in the east, and for 4 km from north to south. As to access; from Hsuan-hua go 5 km to Erh-tai-tzu, turn north then go up along the river bed for 4 km.

In this district, the Sinian system is developed regularly upon the base of Sang-kan gneiss system of Archaearn with unconformity. These two are overlaid by loess, having large scale gulleys, and also by alluvium on mountain foot and low lands.

Gneiss system is denuded extensively resulting in a mature topography, and is distributed widely in the northern portion of this district. The gneiss and Sinian systems, when viewed from their sides, are bordered with steep cliffs, and extend from east to west for over 10 km along the ridge line parallel to the strike. The southern slope of this ridge coincides with the dip of strata, that is about 15 degrees. In other words, the same bedding plane is extensively exposed to present a different topography quite different from that of the northern slope, showing a typical cuesta topography.

There are two or three valleys, deeply incised from south to north with steep slopes on both sides, on its southern slope. The exposure of the iron ore member of the Sinian system is traced from both banks to the northern slope of cuesta ridge, and extends for 15 km from east to west.

The structure of the Sinian system is very simple, dipping at 15 degrees to the

**Table 1.** Correlation Table of Sinian System in Lung-yen Iron Ore Field.

| Locality and Author | | West Part of Ta-tung Reg., Yen-tung-shan Concession (SHOJI and YAMAZAKI, 1951) | Yen-tung-shan Region (NAITO, 1938) | Pang-chia-pu Region (MATSUDA and ASAHI, 1939) | Hsin-yao Region (OTANI and ASAHI, 1939) |
|---|---|---|---|---|---|
| Younger Rocks | | | Jurassic or Cretaceous Conglomerate and Sandstone | Jurassic or Cretaceous Volcanic Rocks | |
| Sinian System | Pang-chia-pu Series | Siliceous Sandstone Member 30 m± | Shui-mo Member 1,000 m | Upper Siliceous limestone Member 450 m± | Upper Siliceous limestone Member 300 m± |
| | | | | Siliceous Sandstone Member 125–150 m | Siliceous Sandstone Member 140 m |
| | | Lower Siliceous Limestone Member 95–110 m | Upper Limestone Bed 30 m<br>Siliceous Clay Shale and Limestone, Alternating Bed 26 m<br>Lower Limestone Bed 50 m | Lower Siliceous Limestone Member 130–200 m | Lower Siliceous Limestone Member 160 m |
| | Yen-tung-shan Series | Green Phyllite Member 10–13 m | Green Clay Slate Member 30 m± | Phyllite Member 20–90 m | Phyllite Member 40 m |
| | | Iron-Bearing Member 20–25 m | Siliceous Claly Slate and Sandstone Member 20 m± | Iron-Bearing Member 3.9–8.9 m | Iron-Bearing Member 7 m |
| | | Quartzite Member 65 m± | Quartzite and Siliceous Clay Slate Member 52 m± | Quartzite Member 80–110 m | Quartzite Member 110 m |
| | | Clay Slate Member 60 m± | Clay Slate Member 150 m | Clay Slate Member 80–90 m | Clay Slate Member 80 m |
| San-kan Gneiss System | | | | | |

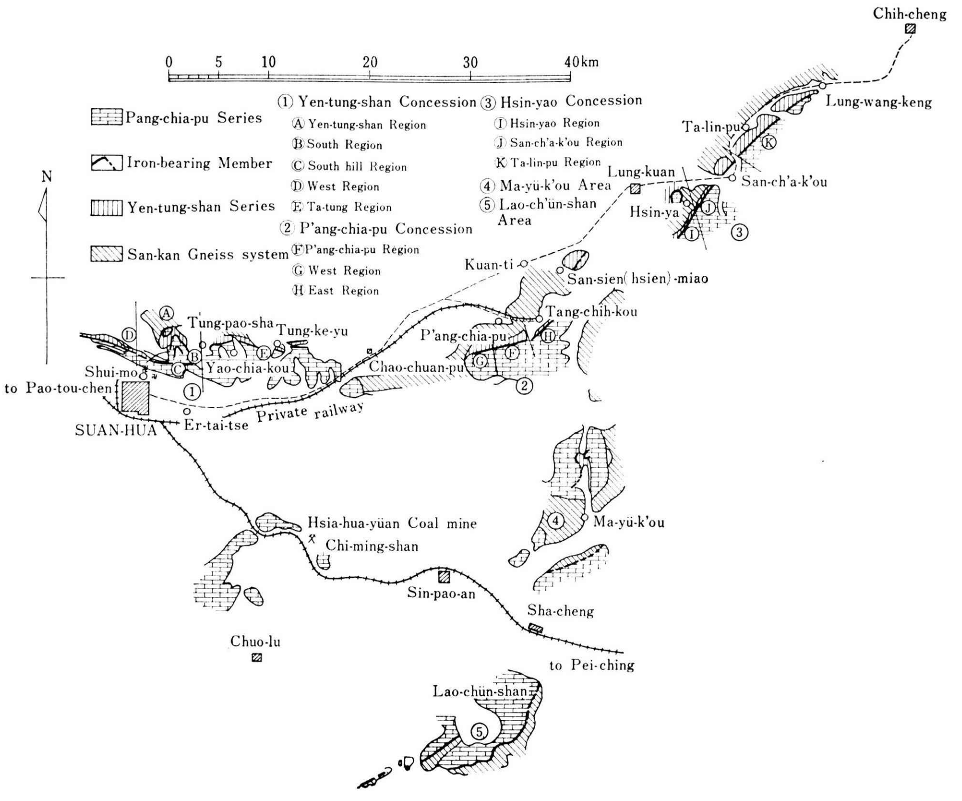


**Fig. 2.** Distribution of iron-bearing member in Lung-yen iron ore field.

south and practically without any folds. There are only two or three minor faults including a hinge fault with a throw of 10 m.

## III. Sinian System

The results of correlation between strata of other concessions of Lung-yen iron ore deposits and those of this region are as follows: Since this region occupies only one part of the iron ore field where the iron ores of this horizon, are exposed, it may not be proper to propose the names of series as shown on Table 1, from the study of this region only. However, the name of Yen-tung-shan and Pang-chia-pu series will be used provisionally for the convenience of explanation.

The Pang-chia-pu series is to be correlated to so-called Nan-kou limestone in the Nan-kou valley, and the continuous exposure of the same horizon is not seen on account of fault, but the complex forms a mountain range. And the Yen-tung-shan series can be correlated to the clastic rock in the lower part of Nan-kou valley and the Ho-shan sandstone in Shan-si Province.

The Sinian system in the area surveyed by us and referred to in this paper, is about 1,900 m or more in thickness, but there is a 280 m geologic columnar section now available (see Fig. 3) only up to the lower part of the Pang-chia-pu series, as shown on Table 1. Even the actual thickness of Upper siliceous limestone only is over 1,500 m, as shown in Table 4, although there is no columnar section. The relation with the Sang-kan gneiss is unconformable, and the truncation of the schistosity of gneiss can be clearly seen from distance. There is no basal conglomerate but a rather arkose siliceous sandstone is seen at the direct contact with the unconformity plane. The unconformity plane has the strike of N80°E and the dip of 35°S, while the schistosity of gneiss is N30–40°E in strike and 35°S in dip, and the Sinian system shows the strike of E–W and the dip of 15°S. This unconformity plane and the Sinian system rest upon the erosion surface of gneiss in an overlapping form,[2] although this feature is seen only locally. This system is sometimes in contact with gneiss by fault in Yen-tung-shan and Hsin-yao, but there is no such occurrence in this region.

### A. Yen-tung-shan Series

This series is a complex of clastic rocks, 160 m thick in this region and 200 m thick in Yen-tung-shan and other places, as shown on Table 1. Marked cross-bedding, sun crack or ripple mark, present the lithic character of shallow water facies. It can be divided into four parts distinctly. Namely, the lower part is phyllitic and siliceous clay slate, and upon it, there occurs thick white quartzite, forming cliffs, and then iron bearing member, and green phyllite in the uppermost part.[3]

The rock facies and the order of strata are equal to three other regions,[4] so correlation is achieved easily. The Yen-tung-shan region[5] is especially so short in distance that characteristics are common between the two, even in particulars.

#### 1. *Clay Slate Member*

This is the thickest, namely 150 m, in the Yen-tung-shan region, 80–90 m in other regions, and thinnest, or 60 m or so, in this region. The rock facies is the same as to those in other regions. It is mainly composed of grayish green clay slate, which is phyllitic and exfoliates imbricately. It is divided into upper and lower parts.

The lower part contains compact and hard siliceous sandstone lenticularly or alternately, and the siliceous sandstone in the basal part, being in direct contact

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2) Possibly cross-bedding.

3) It corresponds nearly to "member" on page 17 of *the Report of Society for Research of Nomemclature of Strata*, and it is doubtful whether it should be called bed simply.

4) Three mine lots, Pang-chia-pu, Hsin-yao and Yen-tung-shan (western half of Yen-tung-shan mine lot).

5) Yen-tung-shan mine lot includes the Yen-tung-shan region, the southern contiguous region of Yen-tung-shan, the south mountain of Yen-tung-shan and the western contiguous region of Yen-tung-shan.

with gneiss, is rather arkose, and is with marked cross-bedding and includes small spots of iron hydrooxide. These sandstones get fine in granularity upward.

The upper part is composed of clay slate and reddish brown siliceous slate in alternation, but clay slate predominates in the lower part, while siliceous slates often contain ripple marks and sun cracks.

2. *Quartzite Member*

This forms remarkable cliffs upon the clay slate member and below the iron-bearing member, so it becomes a good index bed. It gets thick gradually from Yen-tung-shan to the east, as seen in Table 1. It is 65 m or so and often forms white cliffs, 30 m in height.

The quartzite is white, compact and hard, and partly sandy. It is composed of quartzites, 30, 70 and 17 m thick in lower, middle and upper parts, respectively, and two layers of dark purple siliceous slate, from 5 to 6 m thick, are inserted between them. The lower quartzite is abundantly spotted with iron hydro-oxide, 0.1–3 cm in diameter.

This bed has ripple marks and sun cracks all over the bed, especially in siliceous slate.

3. *Iron-bearing Member*

This member is from 20 to 25 m in thickness, and consists of siliceous slate, siliceous sandstone, quartzite, and iron ore beds, as shown in Fig. 3. The rock facies varies in both horizontal and vertical directions remarkably. In short, this is due to the gradual transition among siliceous sandstone, quartzite and ore bed. Therefore the iron ore bed itself is not definite in upper and lower limits, as well as in length and number of layers, but forms irregular lenses, concentrating in two beds, lying in the middle of the iron-bearing member, as seen in Fig. 4.

About 5 m in the uppermost of iron-bearing member is composed of remarkably characteristic siliceous sandstone, and forms cliffs with quartzite members, as already stated, so the location of the ore bed can be pointed out even from a distance. The iron-bearing member is rich in cross beds, ripple marks and sun cracks which will be discussed later, and sun cracks and rain drops, filled with iron, were discovered in Yen-tung-shan by T. Tomita. These evidences and the remarkable variation of rock facies in horizontal and vertical directions suggest an environment of shallow water which often became land. Figure 4 shows a typical sections obtained from about 60 trenches made in this member.

This member is divided into four parts from rock facies. The lower part is mainly composed of bluish gray siliceous slate, often phyllitic, and about 7 m thick. The basal bed, 1 to 2 m thick, is a ferruginous, siliceous sandstone, often interbedded with siliceous slate. At its contact with the underlying quartzite is found a layer, about 1 cm thick and resistant to weathering, which consists of thin lamina of kidney shaped hematite ore of 1 to 2 mm in thickness. In the upper part, sandy iron ore is found which either contains ferruginous sandstone or forms a sandstone rich in oolitic hematite.

The middle part is composed of, in order from below, iron ore bed about 1 m

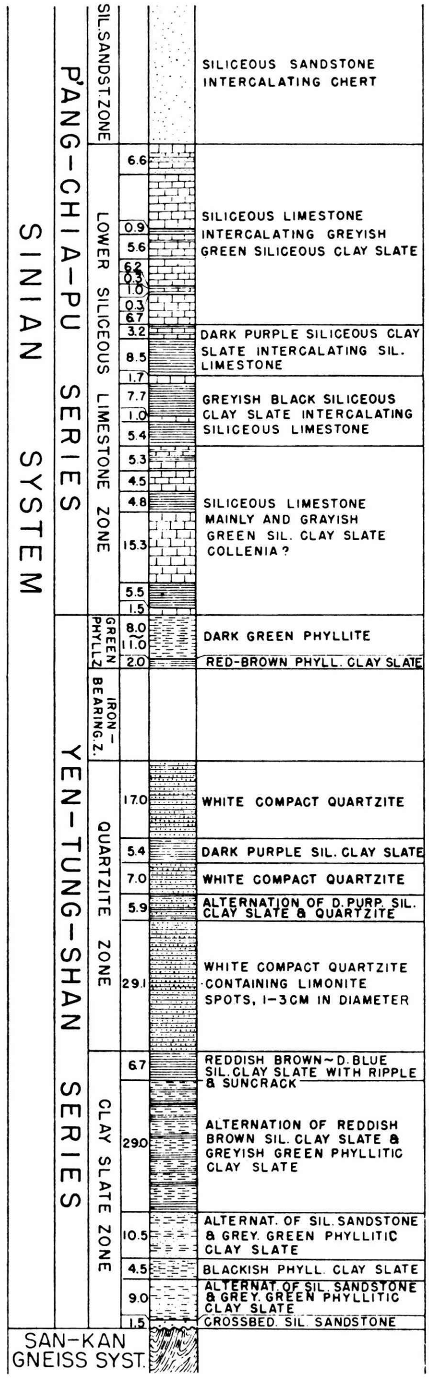


**Fig. 3.** Columnar section of the Sinian system in the Lung-yen iron ore field.

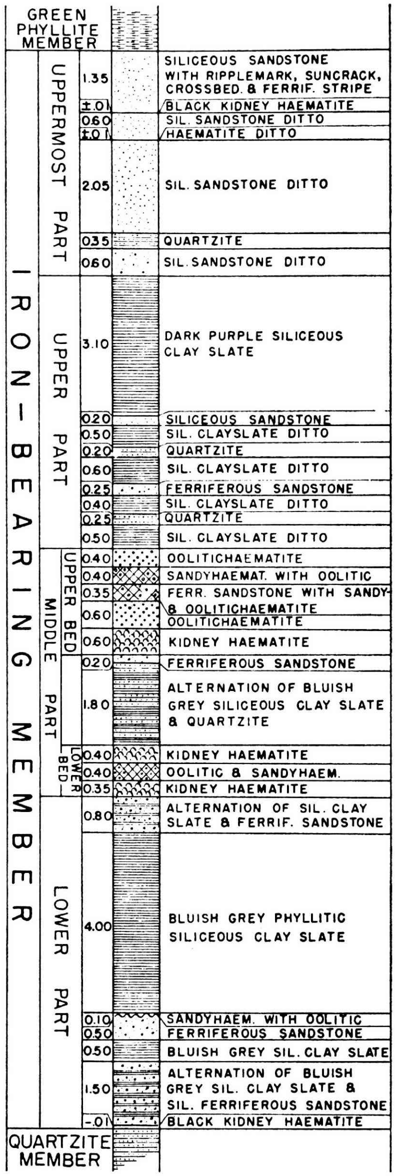


**Fig. 4.** Columnar section of the iron-bearing member.

thick, alternation of quartzite and siliceous slate about 2 m thick, and iron ore bed about 2 m thick, and occupies the important part of iron-bearing member which is about 5 m in its aggregate thickness. Concerning iron ore beds only, there is no one so thick as that of Pang-chia-pu, which is 4 m thick. Generally speaking, they are a little inferior to those of Yen-tung-shan region. These iron ore beds, quartzite, siliceous slate etc. thin out in lenticular shape remarkably even in iron ore-bearing member, and siliceous sandstone transits into ferruginous sandstone or sandy iron ore mutually as has been already stated. Accordingly one of two main iron ore beds sometimes thins out or transits into sandstone to leave another of the two. The combination of kidney, oolitic and sandy iron ores, composing iron ore bed, is not definite, but kidney portion is comparatively more persistent.

The upper part is mainly composed of dark purple colored siliceous slate, and intercalates only ferruginous sandstone and quartzite. This part is rich in sun cracks and ripple marks, and shows the Liesegang phenomenon of precipitation of iron. Sandy and oolitic iron ores are sometimes seen in this bed too.

The uppermost part consists of characteristic siliceous sandstone, about 5 m thick, as already stated, and forms often cliffs, and it is fine grained, compact, grayish white and banded with fine particles of iron, and is rich in cross beds, sun cracks and ripple marks. Green phyllite, lying directly upon an iron-bearing member, is eroded easily to expose this sandstone directly, so characteristic topography as flat platform or smooth slope along the strata, is formed. The lower part of this sandstone intercalates quartzite, about 1 cm thick or so, and kidney iron ore, 1 cm thick, occurs irregularly near the upper limit. This sandstone is developed similarly in Yen-tung-shan region too, but is lacking in Pang-chia-pu and Hsin-yao regions, and green phyllite bed in the upper horizon covers directly the dark purple siliceous slate of the upper part of an iron-bearing member.

**Fig. 5.** Iron ore beds, in San-cha-kou region of Hsin-yao concession. Kidney hematite and the state of alternation of siliceous slate and iron ore bed are seen distinctly. Left: M. FUJIWARA, Right: SHOJI.

3–1. *Iron Ore Beds*

The modes of occurrence of iron ore beds are as stated above. As to the studies from view points of ore deposit, petrology and mineralogy, detailed description has been already done by other authors. These topics are not the main object of this paper, so supplementary description only will be given in the following sections.

The iron ores can be divided into kidney, oolitic and sandy iron ores with naked eye, but there is no fundamental difference among them. Such differences are only due to the state of flow at the time of deposition, the difference in the supplied amounts between iron part and clastic materials,[6] and the difference in the velocities of feed. The origin of formation of oolitic iron ores is explained by many authors as follows: The iron part concentrates to form a film around the nucleus of a quartz particle suspended in water, and it becomes a small ball after rolling, and when it becomes a definite size (weight), it is deposited. In this process, if the iron part is too much and the flow is rather fast, deposition is narrowly performed, and starts only after the iron film gets thick. And if the feed of iron is much, kidney ore is formed. If the feed of clastic matters is much and the flow is slow, and deposition occurs previously before the iron film is formed, sandy iron ore, which is the mixture of oolitic and quartz particle, will be formed.

The oolitic hematite is an aggregate of oolites, 1–2 cm in diameter and equal size, it appears grayish black, and lustrous if fresh, but easily weathers into reddish brown color. Under a microscope, a quartz particle, fresh and rounded, is often seen in the center, but it is sometimes wholly lacking. The interstices among the oolites are often filled with similar quartz particles, but sometimes filled with calcites, M. WATANABE stated that the calcite deposited chemically from solution and always exists. But our comment is rather different from the above. Namely calcite appears as white veinlet in cracks of ore, and gets less in amount gradually away from this veinlet, and it cannot be found in that portion where there is no crack. Therefore the calcites seem to have percolated through cracks in groundwater secondarily, and has nothing to do with ore deposition.

KATO presented a mixture of hematite and clay as the cementing material, but clay could not be found under the microscope.

Quartz grains and quartz grains with their interstices filled with hematites are more in amount than calcite and clay in the cracks around oolites. Under a reflecting microscope, hematites are different to some extent in characters between the portion of oolites themselves and the portion filling their voids. The former is isotropic and tinted with gray color, while the latter is weakly anisotropic, and contains light colored portion, and the latter may be specularite.

After precise observation of the concentric bands of oolite, it is learned that minute needles of crystals radiate from the center of oolite. The whole part but the portion of quartz grain in the center, is composed of these crystals. The origin of bands is regarded as follows: If such crystals, to be formed in radiated shape from

6) Most of them are round particles of quartz.

the center, grows up to some certain length, namely, the film of crystal becomes thick to some extent, new crystal starts growing, and as a result, bands might be formed like annual rings.

The kidney hematite includes two types, i.e., a bamboo shoot-like one and mixed one of a bamboo shoot-like one and oolitic iron ore. The oolitic portion is as stated above. The bamboo shoot-like portion shows structure alike a pile of reverse cone of hematites, but particles of specularite like substance are found irregularly among hematites of this portion. The bamboo shoot-like bodies are arranged nearly in parallel to bedding plane, and each individual forms a gentle projection upward, and its upper surface appears kidney shape. This projection has parallel bands on its side plane, but minute needles of crystals develop perpendicularly to the bands, in the same with oolitic hematite.

The clastic materials[7)] in these hematites are mostly quartz, but minute crystals of augite or zircon, commonly surrounded by hematite, are sometimes seen. These are rounded, but fresh. We did not find any feldspar.

The sandy hematite is an oolitic hematite rich in quartz grains so there is nothing to be stated specially. However, a thin vein, 5 mm long or so, of limonite was seen in the voids on the upper surface. The size is from 2 mm to 5 mm and O-plane and A-plane of octahedron are seen, so the crystal form is that of pyrite clearly and shows a hematite pseudomorph after pyrite. There are many examples of pyrite altered into limonite in Japan, but such examples are rarely found.

**Table 2.** Analyses of Lung-yen Iron Ores.

| | $Fe_2O_3$ | (Fe) | $Si_2O$ | $P_2O_5$ | S | $CaCO_3$ | |
|---|---|---|---|---|---|---|---|
| Kidney Haematite | 96.92 | 67.56 | 1.70 | 0.099 | 0.09 | 0.36 | Extracting conical part, containing no oolite. |
| Oolitic Haematite | 87.12 | 60.72 | 10.55 | 0.17 | 0.11 | 0.71 | |
| Oolitic Haematite | 78.89 | 54.99 | 9.40 | 0.17 | Un-known | 1.61 | Lustrous, black |

The results of chemical analysis are as shown in Table 2,[8)] but as to kidney hematite, only a bamboo shoot-like body was picked up, and oolitic mixtures were excluded. Judging from the results, kidney hematite is almost pure hematite, as is shown by the results of microscopic examination. Oolitic hematite similarly contains rather large amount of $SiO_2$. Those indicated as black lustrous in the table occur in similar mode with hematite pseudomorph after pyrite as stated on the

7) According to KADOKURA (1939), 50% or so of the nucleouses of kidney hematites are quartz grain, 10% or so are amphibole and etc., 10% or so are magnetite or specularite, and the remaining 30% do not seem to have nucleous. Moreover, 90% of the nucleouses of oolitic hematites are quartz grain, 10% are amphibole, biotite altered into limonite, or clay grain. These clay grains may be orthoclase.

8) Analysed values and tenors are noted in details in many papers.

**Table 3.** Generalized Stratigraphic Order of Sinian System in Lung-yen Iron Ore Field.

| System | Series | Formation | Thickness (m) | Lithic Character |
|---|---|---|---|---|
| | | Mesozoic Volcanic and Sedimentary Rocks | | Tuff, conglomerate and red sandstone |
| Sinian System | Pang-chia-pu Series | Upper Siliceous Limestone Member | 1,500 | Blackish gray-grayish white siliceous limestone, intercalating many blackish brown thin lenticular chert layers and reddish brown, blackish siliceous sandy shale. |
| | | Siliceous Sandstone Member | 125–150 | Grayish white siliceous sandstone with ripple mark and cross-bed, intercalating light pink shale in upper part, limestone in middle and brown chert in lower. |
| | | Lower Siliceous Limestone Member | 95–160 | Blackish-grayish white siliceous limestone in upper and lower parts, dark purple siliceous clay slate in middle part, containing Collenia? in lower limestone of the Member. |
| | Yen-tung-shan Series | Green Phyllite Member | 10–90 | Dark green-blackish phyllite intercalating light purple siliceous clay slate. |
| | | Iron-bearing Member | 5–25 | Bluish gray-dark purple siliceous clay slate intercalating quartzite, ferruginous sandstone and 2–3 main iron ore beds. In Yen-tung-shan Concession, uppermost bed of this member is siliceous sandstone frequently cross-bedded, with ripple marks and suncracks. |
| | | Quartzite Member | 50–110 | Hard compact white quartzite, intercalating dark purple siliceous slate, being rich in ripple mark, suncrack and in lower part, limonite spot 1–3 cm in diameter. |
| | | Clay Slate Member | 60–150 | Mainly grayish green-blackish phyllitic clay slate rich in crossbed and ripple mark in upper part, siliceous sandstone in lower part. |
| | | San-kan Gneiss System | | |

**Table 4.** Correlation Table of Sinian System in Lung-yen

| | | Lung-yen Iron Ore Field (SHOJI and YAMAZAKI, 1951) | Nan-kou (TIEN, C. C., 1923) | Western Hills of Pei-ping (HSIE, C. Y., 1936) |
|---|---|---|---|---|
| Cambrian | | | | Man-tou Shale Mem. |
| Cambrian | | | | Ching-erh-yu Limestone Mem. 100 |
| Cambrian | | | | Hsia-ma-ling Mem. 250–520 |
| Sinian | | | | Tieh-ling Limestone Mem. 300<br>Hung-shui-chuang 200 |
| Sinian | Pang-chia-pu Series | Upper Siliceous Limestone Mem. 1,500 | Upper Limestone Mem. 115–1,000 | Wu-mi-shan Limestone Series 1,500 |
| Sinian | Pang-chia-pu Series | Siliceous Sandstone Mem. 125–150 | Quartzite Mem. 52 | |
| Sinian | Pang-chia-pu Series | Lower Siliceous Limestone Mem. 95–160 | Lower Limestone Mem. 78 | |
| Sinian | Yen-tung-shan Series | Green Phyllite Mem. 10–90 | White Quartzite Mem. 115 | Huang-ling Quartzite Series 100–200 |
| Sinian | Yen-tung-shan Series | Iron-bearing Mem. 5–20 | Clay Slate and Shale Mem. 63 | |
| Sinian | Yen-tung-shan Series | Clay Slate Mem. 60–150 | White Quartzite Mem. 43 | |
| | | Sang-kan Gneiss System | | |

above. It appears on the surface of limonite filling cracks, and presents minute oolite, 0.5 mm, and kidney, 2 mm or so. They have a slightly resinous feel, and are purplish black in color, and not weathered even in outcrop. The analysed values show reduction of the amount of Fe, but no difference is found under a reflecting microscope. Besides, these analysed values are neither the average values nor those representative of the iron ore bed. They are for the small number of specimens now on hand.

4. *Green Phyllite Member*

This member is dark green partly dull colored characteristically, so it is clearly

Iron Ore Field and Ho-pei.

| Chi-hsing-lung (Kao, C. S., 1934) | | Ching-liang-shan (Ozaki, 1940) | | |
|---|---|---|---|---|
| Man-tou Shale Mem. | | Man-tou Shale Mem. | | |
| Tsing-pei-kou Series | Ching-erh-yu Limestone Mem. 150 | Ta-liu-shu Series | Up. Mem. | Limestone and Marl 190 |
| Tsing-pei-kou Series | Hsia-ma-ling Mem. 360 | Ta-liu-shu Series | Low Mem. | Shale, Sandstone and Conglomerate 85 |
| Chi-hsien Series | Tieh-ling Limestone Mem. 350 | Chao-bai-hu Series | Upper Mem. | Limestone 750 |
| Chi-hsien Series | Hung-shui-chuang Shale Mem. 200 | Chao-bai-hu Series | Upper Mem. | Siliceous Sandstone 50 |
| Chi-hsien Series | Wu-mi-shan Limestone Mem. 1,150–1,500 | Chao-bai-hu Series | Lower Mem. | Limestone 300<br>Shale 300 |
| Chi-hsien Series | Yang-chuang Shale Mem. 410 | Chao-bai-hu Series | Lower Mem. | Limestone 400 |
| Nan-kou Series | Kao-yu-chuang Limestone Mem. 300–1,500 | Ching-liang-shan Series | Siliceous Sandstone and Shale Mem. 195 | |
| Nan-kou Series | Ta-hung-yu Quartzite Mem. 50–400 | Ching-liang-shan Series | Siliceous Sandstone and Conglomerate Mem. 300 | |
| Nan-kou Series | Chuan-ling-kou Shale Mem. 480 | Ching-liang-shan Series | | |
| Nan-kou Series | Chang-cheng Quartzite Mem. 650 | Ching-liang-shan Series | | |
| Tai-shan Gneiss System | | Wu-tai System | | |

distinguished when viewed from a distance. It easily exfoliates along schistosity, and weathers into pieces. Naito (1938) described this as green clay slate in Yen-tung-shan, but we will assume it to be a phyllite member in order to match to the description of Hsin-yao and Pang-chia-pu. As already stated, it is eroded to large extent, and in extreme case, it is eroded out and limestone bed in the upper horizon covers directly the siliceous sandstone of the uppermost of iron-bearing member.

B. Pang-chia-pu Series

It overlies Yen-tung-shan series, consisting of clastic rocks, and is mainly composed of siliceous limestone, and intercalates siliceous sandstone, and amounts to several thousands meters in thickness. It is to be correlated to so-called Nan-kou limestone, in Han-kou valley, and this paper adopts the order of strata, already described in Pang-chia-pu and Hsin-yao for the type. NAITO proposed the Shui-mo member, new in Yen-tung-shan and correlated the underlying strata to Nan-kou limestone, but the Shui-mo member is clearly correlated to one part of the siliceous sandstone and upper siliceous limestone in Pang-chia-pu actually as seen in Table 1. And the Shui-mo member and its lower strata were summed in Pang-chia-pu series, because there is neither need nor reason to divide them into two.

This is correlated to Tien's order of strata in Nan-kou as shown in Table 4. The thickness of strata amounts to more than 1,000 m in maximum. The Pang-chia-pu series is covered by volcanic rocks or clastic rocks of the Jurassic or Cretaceous period in Yen-tung-shan and Pang-chia-pu, but it is confirmed that these younger deposits are lacking in this region, and upper siliceous limestone member extends, thickening southward, beyond this region.[9] However, we could not make a survey, because it was not the object of present investigation.

1. *Lower Siliceous Limestone Member*

This member mainly consists of siliceous limestone, and is from 95 to 110 m thick, and is exposed often in cliffs upon green phyllite members, and coincides more with the lower strata than the Shui-mo member after NAITO. It can be divided into three as NAITO did, but the boundaries are not clear on account of gradual transition.

About 35 m in the lower part is mainly composed of dull colored siliceous limestone, with intercalation of grayish green siliceous slate. The limestone is very siliceous, and is weathered to be light yellow colored. Siliceous slate increases gradually upward to form an alternation. The basal part of limestone shows concentric pattern of the Liesegang type in transverse section and reverse cone structure in longitudinal section, but these may be possibly *Collenia.* No one gave notice to *Collenia* in the Lung-yen iron ore field at that time, and at this juncture we can refer to only to TAKAHIRA's description that *Collenia* is thickly concentrated in this horizon and the upper horizon in Hsuan-hua. They seem to resemble in origin ferruginous concentric structure, seen in dark purple siliceous slate of the upper part of an iron-bearing member, already stated, and also to kidney hematite. If these are *Collenia* actual, a doubt may be dispelled about the idea that *Collenia* is due to algae. It is regrettable that there is no way to advance discussion with the data on hand.

About 30 m in the middle part is chiefly composed of dull or dark purple colored siliceous slate (varies into grayish green upward and downward), and intercalates thin bed of limestone.

The upper part is about 30 m thick too, starts from alternation of limestone and

9) See the article on the Sinian system as to the thickness used for the formation of geologic column and those simply measured.

grayish green siliceous slate, and changes into siliceous limestone with intercalation of thin bed of siliceous slate, rarely siliceous sandstone. The rock facies of limestone is equal to the lower part, but gets compact upward, and sometimes contains marly portion.

2. *Siliceous Sandstone Member*

This is thickly developed regularly to the south of the region. The strata are mainly composed of grayish white siliceous sandstone, and involves bands of thin beds of chert, brown or bluish green colored, compact, hard and sometimes irregular due to intraformational folding. As the result of selective weathering, chert is relieved to show clear pattern. This member has such characteristic bed as stated on the above, so it is easily correlated to other regions.

The upper part of this member includes so called red colored bed, including light red or purplish brown sandy shale, described in Hsin-yao and Pang-chia-pu, and suggests the deposits of specially dry climate. It is regarded as of Jurassic or Cretaceous period.

3. *Upper Siliceous Limestone Member*

This paper will not discuss the upper limit of this member, because it is in areas outside of this region, but the thickness of strata within this region amounts to more than 1,500 m. This member includes white chert, and sometimes the whole part is siliceous, and sometimes consists of dolomite or dolomitic rocks.

One of us (SHOJI, 1950) has already published a paper describing briefly the rock facies and other aspects of this member.

## IV. Correlation to Sinian System in Ho-pei Province

The order of succession of strata of this system within the Lung-yen iron ore field is correlated as shown in Table 1. This is further summed up in Table 3.

Many papers were published about the Sinian system of North China and the correlation to the strata in Manchuria and Korea, but there are many problems not yet solved. The object of this paper does not include the examination of these problems, so the correlation of those of Lung-yen iron ore field was done only with those of the Northern part of Ho-pei, such as Ching-liang-shan described by OZAKI (1941), Chi-hsien and Hsing-lung-hsien described by KAO (1934). The western hills of Peiping by HSIEH, etc., stratigraphical sequence of all of which were described recently and in details by OZAKI. The correlation among the above stated localities, except for Lung-yen, Chi-hsien and Hsing-lung-hsien had already been done by OZAKI. His correlation between Ching-liang-shan and western hills of Pei-ping is quite equal to Table 4. However, our comment is different from his, where he correlated so-called Nan-kou limestone by Tien to the whole of Chao-bai-hu series. It is stated in Article 3 B of the Pang-chia-pu Series, that TIEN's Nan-kou limestone is correlated to the Pang-chia-pu. But Judging from order of succession, rock facies, thickness and etc., the lower part of the Chao-bai-hu series is correlated to the Pan-chia-pu Series. Consequently the lower part of the Chao-bai-hu, Nan-kou limestone and Pang-chia-pu series are arranged as shown in Table 4. Discussing further in detail, it follows that the shale of the lower part of Chao-bai-hu series is a heteropic facies of sandstone of the Pang-chia-pu series and quartzite of Nan-kou. Namely, all of them present distinct red color, indicating a dry climate, intercalate chert, have limestone in both upper and lower horizons, and include *Collenia* and chert. In short, they have many features in common. However, as to TAKAHIRA's *Collenia* from the lower limestone bed, TIEN (1923) observed them in the same horizon at Nan-kou too, but they are not described from Ching-liang-shan.

The correlation between KAO's Chi-hsien and Hsing-lung-hsien and Hsieh's western hills of Pei-ping is published as shown in Table 4 by the latter.

Comparing thickness of strata among the places in the table, KAO's complex, occupying the central portion of the area in the table, is remarkably thick, especially in the portion to be correlated to the Yen-tung-shan series. KAO emphasized the repetition, because of the two limestones, Kao-yu-chuang and Wu-mi-shan. But HSIEH (1936, 1937) could not distinguish two limestones from each other in the western hills of Pei-ping, so he summed them up in Wu-mi-shan limestone and did not state anything about the repetition. Anyhow, it shall be explained that the Pang-chia-pu series simply grew thicker in KAO's region.

If the above is true, the red shale member of Yang-chuang shall extend from east to west as it is, and shall serve as an index bed, even if it varies in its thickness.

The clastic rocks in the lower part of these thick limestone complexes are all correlated to the Yen-tung-shan series. HSIEH summed up in the Huang-ling quartzite the portion to be correlated to the Yen-tung-shan series after KAO in the western hills of Pei-ping because of thin thickness of the strata. KAO stated, after his inspection of the so called Yen-tung-shan series in Hsuan-hua, that the strata can be roughly correlated to the Chang-cheng quartzite and an upper member. OZAKI correlated the Ching-liang series to Huang-ling shale. Taking the above into consideration, quartzites in Nan-kou too shall be as a matter of course correlated to this horizon.

These are clastic complexes, so it is difficult to correlate them in detail in accordance with their rock facies only, but all are rich in cross beds, ripple marks and sun cracks, show shallow water facies and include characteristic limestone in the upper part, therefore these can be correlated roughly to each other. Iron ore beds seem to occur in the same horizon with that of the Yen-tung-shan series not only in the area cited on the table but all over North China. It is said that hematite occurs in Ching-hsing district and in Ho-shan, and according to TOMITA (1939). He discovered a boulder of kidney iron ore from the Nan-kou valley, and Li described a low grade iron ore, which transits gradually into septaria, 20 m thick, in the basal part of the Sinian system in the northeastern part of Ho-pei Province. These facts are interesting in showing the uniformity of rock facies.

Considering the thickness of these clastic rocks, the basin where these were deposited, has its center in Chi-hsien and Hsing-lung-hsien surveyed by KAO, and extended over to Nan-kou and Lung-yen in the west and further westward, to Ching-liang-shan in the east, and to Ching-hsing and Ho-shan in the south. And iron ores were deposited in various places, where the depths were moderate within the basin.

The base of the Sinian system consists of the Wu-tai system or Gneiss system, but the Wu-tai system as described by Tien at Nan-kou, has been amended by TOMITA, on the basis of a contact of intrusive rock of Post-Sinian period. Accordingly it was excluded from the table. Besides, according to him, he suspects that there is a similar case about the Wu-tai system in the base of the Ching-liang series.

The correlation of the upper strata than the Pang-chia-pu series is out of our scope of study, so the table was made in accordance with OZAKI's and HSIEH's.

However, LI found *Redlichia* of Lower Cambrian period from Ching-erh-yu limestone, and the limestone covers Hsia-ma-ling shale with conformity clearly. Therefore the para-unconformity lying beneath it was taken for the upper limit of the Sinian system.

The following is added, although all the occurrence are outside of the area concerned in this paper. YAMANE, HSIEH, KAO and WATANABE are not agreed, as to the correlation with each other of Tung-yu limestone, Tou-tsun clay slate or Tai-yang limestone, in Hu-to system by WILLIS and BLACKWELDER, and Sinian system of Shan-si Province.

## References


ASAHI, N. (1939),* San-sien-miao. Southern Manchuria Railway Co.

GRABAU, A. W. (1923–24), Stratigraphy of China.

HSIEH, C. Y. (1936–37), An Outline of Geologic Structure of the Western Hills of Pei-ping. *Bull. Geol. Soc. China*, vol. 16.

KADOKURA, M. (1939), Iron Ores and Sulphide Ores of North China.

KAO, C. S. (1931), Preliminary Notes on Sinian Stratigraphy of North China. *Bull. Geol. Soc. China*, vol. 3, p. 264.

KATO, T. (1937), *Geology of Ore Deposits*, p. 480.

LEE, J. S. (1939), Geology of China.

MASUBUCHI, K. (1942),* The East and West Regions of the Pang-chia-pu Concession. North China Development Co.

——, (1943),* The Southern Region and South Hill Region. North China Development Co.

MATSUDA, K. and ASAHI, N. (1939),* Pang-chia-pu. Southern Manchuria Railway Co.

NAITO, T. (1938),* Yen-tung-shan, Lung-yen. South Manchuria Railway Co.

OTANI, H. and ASAHI, N. (1939),* Hsin-yao. Southern Manchuria Railway Co.

OZAKI, H. (1941), Sinian System in the Environs of Ching-liang-shan, in Hopei Province (Northern Margin of the Kai-luan Coal Field). *Jour. Geol. Soc. Japan*, vol. 16.

SHOJI, S. (1942),* The San-chia-kou Region. North China Development Co.

——, (1950), Limestone of North China. *Tohoku Kozan*, vol. 2.

—— and YAMAZAKI, T. (1941),* The Ta-tung Region. North China Development Co.

TEGENGREN, F. R. (1921), The Iron Ores and Iron Industry of China. *Mem. Geol. Surv. China*, Series A, no. 2, Oct.

——, (1923), Ibid., Dec.

TIEN, C. C. (1923), Stratigraphy and Palaeontology of the Sinian Rocks of Nan-kou. *Bull. Geol. Soc. China*, vol. 2, nos. 1–2.

TOMITA, T. (1939), Rocks of North China. *Kagaku*, vol. 9, no. 5.

WATANABE, K. (1939), General Remarks on the Geology of China. *Jour. Geogr.*

WATANABE, M. (1923), An Outline of the Lung-yen Iron Ore Deposits. *Jour. Japan. Assoc. Mineralog., Petrolog. and Econ. Geolog.*, vol. 21, no. 3.

WILLIS, B. and BLACKWELDER, E. (1907), Research in China.

YAMANE, S. (1931), Geologic History of China. *Iwanami Koza.*

* A restricted edition for use only by the Japanese Government.