On the Gold Ore Deposit of Chia-pi-kou and Lao-chin-chang

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1. Location

The mines are located at about 170 km east of Pan-shih Station on the Feng-tien-Chi-lin Line. There is an automobile road between the station and the mines, but it has to cross the Sung-hua-chiang River twice, at Hua-tien and Hung-shih-la-tzu and the wooden bridges at these points are subject to damage. In addition, the river course above Hung-shih-la-tzu meanders and in many places the road has been cut in the cliffs and has many curves and changes in grade.

The ore is transported between Lao-chin-chang and Chia-pi-kou by means of an aerial ropeway, but men and materials have to depend upon truck service over the road, which is 16 km long.

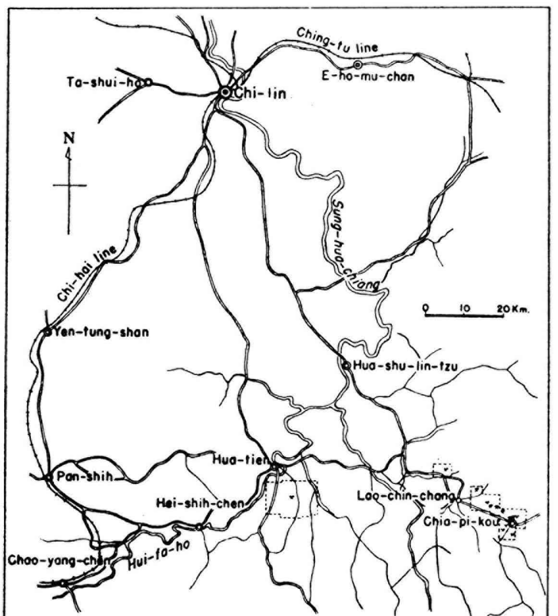

Fig. 1. Map Showing the Location of Chia-pi-kou and Lao-chin-chang Gold Mines.

2. History

Placer gold fields in Manchuria were discovered by smugglers of ginseng during the Ching dynasty. The gold fields were exploited in accordance with the size of the deposits, and Chia-pi-kou and Lao-chin-chang are among the most famous gold fields.

The valleys of Chia-pi-kou were worked out everywhere by multitudes of Chinese from the downstream area. At the top of the creek they discovered a large outcrop of a gold-quartz vein, more than 4 m wide, and the mining operations were changed from placer mining to gold vein mining. At the peak period, around 1847, the number of men mining gold was reported to be forty thousand.

The gold-quartz vein was divided along the outcrop into appropriate lengths, and a gang including as many as thirty persons was assigned to work each section. The old names of pits, such as Pa-jen-pan and Shih-san-jen-pan, literally "eight-man gang" and "thirteen-man gang," remind us of the ancient work system.

Because of primitive mining methods, the work may have been checked in some places by gushing water. However, important bonanzas were worked to greater depths by setting closely-spaced wooden pumps along the slope and removing water by a relay method with hand buckets.

The rich ore may have been worked by a selective mining method, as the pillars left in the old work places show a grade of over 10 gr of gold per ton, hence the crude ore at that time may have been richer than 20 gr per ton.

In 1902, just after the North Manchurian Incident, Russians entered the area and set up a boiler plant preparatory to starting mining operations, but they left at the outbreak of the Russo-Japanese War in 1904. In 1915 mining rights were obtained by a Sino-Japanese corporation, but the mine was not taken over and no enterprise resulted.

Since then, the actual administrative rights of the mine remained in the hands of the Han family, descendants of the initial owner of the mine.

In June 1938, upon investigation of the mine, the Manchurian Mining Company (Manshu Kozan K. K.) decided to reopen the mine and introduce modern mining methods. The company established an all-sliming flotation plant with a capacity of 3,000 tons a month at Chia-pi-kou and planned to start exploitation there.

Later, Lao-chin-chang was transferred from the Manchurian Gold Mining Company to the Manchurian Mining Company. Regular operation of the Chia-pi-kou mine was begun in 1940, and of the Lao-chin-chang in 1942, but security and transportation problems have greatly hampered the construction work.

Separate descriptions will be given of these two mines.

3. Geology and Ore Deposits

A. Chia-pi-kou Mine[1]

1. *General geology*

The rocks present in the mine area may be classified as follows:

Gneiss group
- Amphibole granite gneiss
- Injection gneiss
- Aplitic granite gneiss
- Amphibole diorite
- Amphibolite
- Hornfels

Dike rocks
- Porphyrite
- Porphyry
- Felsite
- Spherulitic granophyre

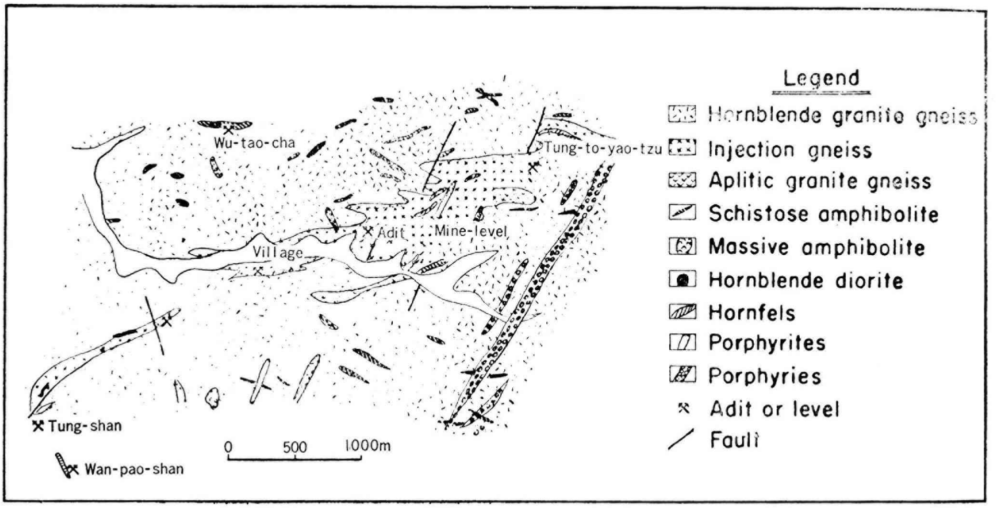

Fig. 2. Geological Map of Chia-pi-kou Gold Mine.

Amphibole granite gneiss is widely distributed in this district, and poorly defined bands of injection gneiss striking northeast within the granite area form an important ore zone. Hornfels appear in a schlieren-like form along the schistosity only in the central part of the injection gneiss. Hornfels are not seen in the sur-

[1] M. Hotta made a detailed investigation of the mine for his graduation thesis during the author's tenure of office there. The material for the major part of this chapter was supplied by his investigation.

rounding hornblende granitic gneiss. Amphibolite is generally not present in the central part of the injection gneiss, but is commonly found along the schistosity of hornblende granitic gneiss, and in deposits of various sizes. The planes of schistosity of the gneiss group generally trend E-W, and dip 20°–50°S. However, the trend of the gneiss group located east of the main adit is N70°–80°E and to the west the trend becomes N70°–80°W so that the schistosity trend forms a convex curve bending southward. The dip angle of the schistosity varies only slightly. But there is an area between the Honko pit and Tung-to-yao-tzu where the strata are almost horizontal, and around Tung-shan-chin-chang in the south dips are as gentle as 20°.

A noteworthy feature is the relation between injection gneiss and hornblende gneiss. The injection gneiss may be seen as large roof pendants within the hornblende granite gneiss, and the injection gneiss masses are apt to become narrower deep underground. The trend of injection gneiss is generally northeast on the surface, but at its boundary with the hornblende gneiss interfingering occurs underground, though it may be obscure. The branched portions generally trend east in accord with the general trend of schistosity of the district.

The amphibolite in the honrblende granitic gneiss often shows sharp boundaries, but the boundaries of the other gneiss types are generally not clear.

Hornfels and ordinary amphibolite are found within the injection gneiss and hornblende granite gneiss, respectively, as schlieren-like inclusions or as roof pendants parallel to the schistosity. The widths of the distinctive masses generally range from 1 to 10 m.

Hornblende diorite and aplitic granite gneiss are thought to be injections into other types of gneiss. Hornblende diorite is found underground at Tung-to-yao-tzu as an extremely small mass; its relation to the gneiss is not clear. It may represent a magma of aplitic granite gneiss at its end period. The rock is fine- or medium-grained and might be properly called gneissose granite; it also has intercalated amphibolite.

The majority of the faults of the district strike within a range of N20°W to N30°E and are almost vertical. They cross the schistosity at nearly right angles. A fault at the eastern end of Pa-jen-pan has a throw of over 100 m, but elsewhere the throw is generally not more than 10 m.

Dikes generally have an orientation similar to the faults of this district. As stated above, the rock can be divided roughly into a gneiss group and dikes. The gneiss group shows a common schistosity trend. It is generally characterized by such features as richness of epidote; presence of mosaic-like, fine-grained green mica; formation of green mica from the cleavage or the periphery of hornblende, where the latter is present; and remarkable saussuritization of plagioclase. These characteristics may be the result of certain deuteric actions affecting the gneiss group.

Dikes are also generally subject to deuteric action, but they fail to show as many mineralogical similarities as the gneiss group. However, there are dikes intermediate between porphyry and spherulitic granophyre in character, which indicates that the rocks may form a series.

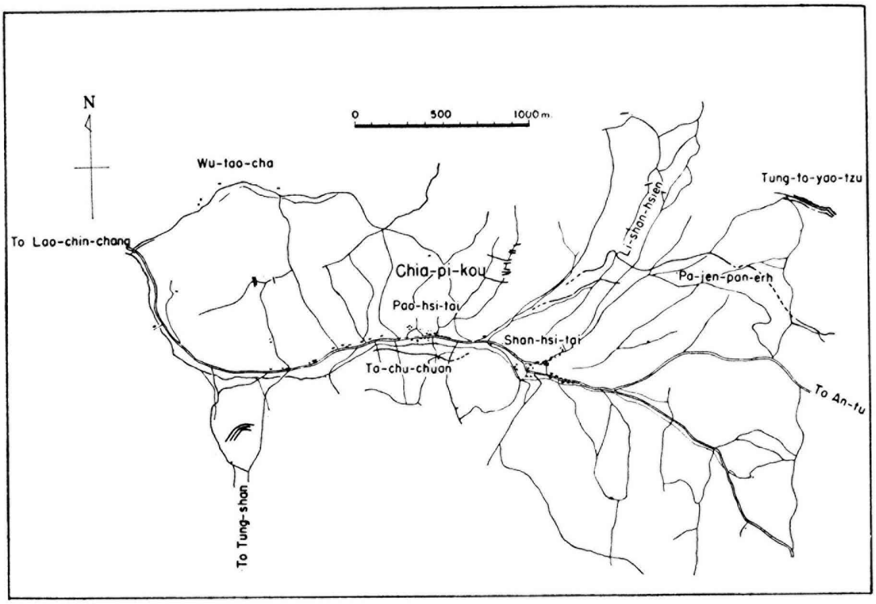

Fig. 3. Map Showing the Distribution of Gold-bearing Quartz Veins at Chia-pi-kou Gold Mine.

2. *Ore deposits and ore*

Within the Chia-pi-kou area, exploitation proceeded at Tung-ta-yao-tzu, Pa-jen-pan main pit, Li-shan-hsien, Ta-chu-chuan, Hsia-hsi-tai, Chu-pao-shan, Tung-shan, Wan-pao-shan, Wu-tao-cha and elsewhere.

Of these locations, the Pa-jen-pan main pit, Li-shan-hsien, Hsia-hsi-tai, Tung-shan, and Wu-tao-cha were thought to be the most promising. The vein at Pa-jen-pan, with a uniform thickness of over 4 m, and the several veins at Li-shan-hsien with thicknesses ranging from 50 to 100 cm, are the best veins of the mine.

The dip and strike of these veins is generally in accordance with that of the country rock, and so the veins of the northern side are at an apparently lower horizon. Thus, Tung-to-yao-tzu———Pa-jen-pan, Li-shan-hsien———Hsia-hsi-tai———Chu-pao-shan———Tung-shan is the apparent order of succession. Wu-tao-cha is located on the western extension of the Tung-to-yao-tzu vein and extends for about 2.3 km.

a. Subsurface geology

As stated above, the mine has numerous ore veins, which were worked by Chinese miners as deep as the ground water level or even deeper. Prospecting tunnels were driven by Japanese engineers after the reopening of the mine, and the veins have now been surveyed in detail. As a result working faces have been confined to Pa-jen-pan, Li-shan-hsien, Tung-shan, and Wu-tao-cha.

The main pit and adit were opened to work Pa-jen-pan and Li-shan-hsien from the hanging wall side and in a direction oblique to the strike line. The shaft of Hsia-hsi-tai was driven from the hanging wall side to the vein. Level pits were driven at Tung-shan and Wu-tao-cha from outcrops; but at Tung-shan, a crosscut tunnel was built 30 m below the main level for use as a haulage road as the mining work progressed.

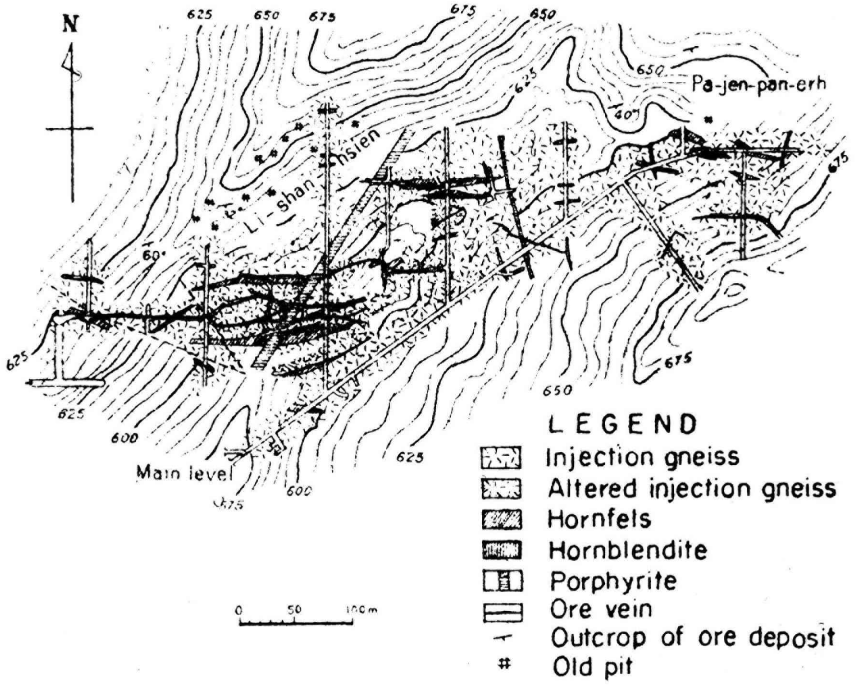

Fig. 4. Underground Map of the Main Level of Pa-jen-pan-erh Mine (According to M. HOTTA)

The vein of Pa-jen-pan has been prospected and mined by the main pit and adit. At its west end the vein has been changed into siderite, thin stringers of which occur within the undulating hornfels. By carefully tracing the thin, white stringers, a quartz veinlet 5–10 cm thick was seen to reappear in the driving head. Its thickness increases to 40–50 cm at a spot about 40–50 m to the east, and at last the veinlet becomes a solid vein more than 2 m thick.

The main body of the Pa-jen-pan ore vein is generally 2–4 m thick, and has scores of smaller veins branching from it on the foot wall side. Each branch vein has a thickness of 5–20 cm and contains much pyrite and a minute amount of chalcopyrite. The veins have a high gold content and may contain scores of grams of gold per ton. Some of the old workings are thought to be relics of selective mining on the bonanzas of branch veins. The main vein of Pa-jen-pan has a horizontal extension of about 400 m and is as thick as 8 m at its east end, where it is faulted by a vertical fault which trends north. This fault is the largest one of the area, but it cannot be detected at the surface. Two prospecting tunnels were driven through the fault plane to search for the extension of the vein, but failed to reveal the vein within a distance of 100 m.

The walls of the main vein consist of hornfels or schist; however, to the south, they dip down and become thin and the vein tends to border directly on the gneiss.

A characteristic of the Pa-jen-pan is the absence of parallel veins. There are a few quartz veinlets, but they are quite barren of gold.

Li-shan-hsien is found within the western extension of the hornfels zone that forms the country rock of the Pa-jen-pan deposit.

The zone may also be called, more broadly, a zone of injection granite, but in many cases the rock constituting the walls of the veins is found to be either fine-grained mica schist or hornfels. Such wall rocks may not be more than several meters thick but are a noticeable characteristic.

The biotite schist contains small isoclinal folds on the walls of the ore veins, and in some spots the veins are seen to run along a gently inclined fault plane.

Li-shan-hsien has as many as 10 parallel veins which are interlaced to form a large network.

The length of the veins ranges from 80 to 120 m, and the thickness from 50 to 100 cm, but the horizontal extension of a vein rarely exceeds 250 m. If the veins should extend into an anticlinal structure of the country rock, they would gradually become thinner or eventually peter out.

The veins are generally rich in sulphide, and portions contain visible gold grains.

An interesting point is the fact that a horizon corresponding to the extension of the Pa-jen-pan vein, namely some lower veins of Li-shan-hsien, contained scheelite in many places, although gold was not necessarily plentiful in this part.

Wolframite is rarely found in the rich ore, which is filled with chalcopyrite-gold-bithmuthinite-galena-quartz stringers according to the report by Hotta. The author unfortunately has failed to discover such ore during several years of studying this mine in operation. On the basis of his experience, the author believes that the rich ore of the mine, associated with chalcopyrite and galena, might correspond to the upper veins of Li-shan-hsien.

Li-shan-hsien, with a uniform gold content, generally 10–15 gm per ton, is a very important site in the mine. The veins of Li-shan-hsien are narrow to the west for a distance of 120 m and then fade away.

The country rock at the western part shows a gradual transition from dark green mica schist to injection gneiss, and with detailed measurement of the dip angles a gentle anticline structure can be detected there. The dip tends to become gentle in the part where the veins fade away.

The character of the veins and the grade of ore at Pa-jen-pan and Li-shan-hsien have obviously been influenced by the character and structure of wall rocks. The veins are pierced by N-S trending dikes but the dikes do not appear to have affected the grade of ore of the veins.

The veins of Hsia-hsi-tai are found on the southern bank of the stream that flows south of the village of Chia-pi-kou. They should lie at a horizon of about 200 m, stratigraphically higher than the uppermost vein of Li-shan-hsien.

The outcrop was disturbed by random workings in the past, but pieces of rich ore, often as high as 100 gm of gold per ton, were obtained from the refuse dump. Therefore, a shaft was sunk there to pursue the veins. As a result, two ore veins with thicknesses from 30 to 50 cm were encountered. They have a general E-W strike and dip 25°S. The lower vein contains a higher grade ore. It diverges into two veins which reunite further on. The length along the strike is more than 100 m, and the ore assays at 7–8 grams of gold per ton. It is characterized by a country rock of dark gray mica schist (farther outside there is an injection gneiss), and also by the presence of some galena in the ore vein. The galena consists mainly of small crystals of less than 1 mm, and the crystal form is scarcely visible to the naked eye. The lead content of the vein is less than 0.5 percent, and thus of no commercial value. Unlike Li-shan-hsien, the Hsia-hsi-tai vein does not contain scheelite.

The Tung-shan vein is located at about 2.8 km southwest of the main adit. It occurs in a horizon higher than that of the vein of Hsia-hsi-tai. It has a strike of N 60°E, dips 20°S, and is nearly parallel to the veins of Li-shan-hsien and Hsia-hsi-tai. The Tung-shan vein has not been developed deep underground, so the interval from there to the Hsia-hsi-tai vein is not known. The distance has been roughly estimated to be 200–300 m. The Tung-shan vein has a total length of 400m, of which 100–120m are fairly uniform, with an enlarged portion of about 2m, but the western end becomes gradually thin. The eastern end of the vein is exposed on the surface, and has been eroded, but the deeper part has not yet been worked. It contains pyrite, a minute quantity of chalcopyrite, and small crystals of galena. In places a grade of 3 per cent lead is maintained for a horizontal distance of 20 m. Zincblende is also contained in minute amounts, but is invisible to the naked eye.

This vein has the lowest gold content of all the veins in the Chia-pi-kou area, having an average of 4–5 gm of gold per ton.

The vein of Wu-tao-cha is located 1.3 km northwest of the main adit, and 1.7 km west-northwest of the veins of Li-shan-hsien. It is thus some distance from the other veins of Chia-pi-kou. The area around the vein consists of hornblende granite gneiss, but the immediate wall consists of several meters of schist, which is a prospecting criterion. The main ore consists of chalcopyrite and pyrite, with a copper content of 0.5–0.6 per cent, but the gold content is not high, being possibly 5–6 gm per ton. The vein has a length of 100 m, and for the most part, has a thickness of 20 cm. Only very rarely is it more than 50 cm thick.

b. Ore

Throughout the veins of the Chia-pi-kou area, the ore consists mainly of translucent white quartz. Although the ore is not characterized by banding or brecciation, the sulphide minerals are often arranged in obscure bands.

In the case of the Tung-shan veins, the galena assumes a banded arrangement at the central part of the vein.

The gold is apt to be accompanied by sulphides, especially pyrite and chalcopyrite. The copper content rarely exceeds one per cent. The ore can be roughly divided into the following five types:

Type 1. The ore consists mainly of chalcopyrite and pyrite with associated magnetite and pyrrhotite; this is the dominant and the rich-ore type in Chia-pi-kou. The ore minerals are primarily in small crystals scarcely visible to the naked eye, but the pyrite of Pa-jen-pan is rather coarse, not infrequently attaining a size of several millimeters.

Under the microscope, the ore rich in sulphide minerals shows an undulating, brecciated structure of vein quartz. Pyrite appears in vein form within the brecciated part of the quartz, and chalcopyrite fills the fissures of pyrite. In a few cases pyrrhotite and gold-grains are in association with chalcopyrite.

Representative localities of this ore are Pa-jen-pan and Li-shan-hsien, the latter having an especially high copper content, for the most part over 0.3 per cent, and containing over 20 gm per ton of gold. However, the amounts of copper and gold are not necessarily proportional.

Type 2. Magnetite, sericite, and a little calcite are crowded together to form gray-black bands.

Type 3. This is a rich gold ore containing tabular crystals of wolframite, and a large amount of associated chalcopyrite and pyrite. Ore of this type was reported by HOTTA to occur very rarely, and the author could not obtain any such sample, even after careful inspection underground. Because of the nature of the ore it is probable that the type might be found at Pa-jen-pan or Li-shan-hsien.

Type 4. Ore containing scheelite is found in the lower vein of the western part of Li-shan-hsien, and in the low grade ore. The ore has a rather low sulphide mineral content, and crystals of pale brownish scheelite of finger to head size are scattered throughout the white quartz. Portions, however, contain 0.3 per cent WO_3 (tungsten oxide).

Type 5. Ore with galena and pyrite is present in the veins of Tung-shan. Ore of this type occurs in the uppermost horizon of the Chia-pi-kou area.

The ore veins of Hsia-hsi-tai are intermediate between type 1 and type 4 and contain pyrite, chalcopyrite, and a little galena.

3. *Ore minerals and paragenesis*

a. Ore minerals

As far as the ore minerals within the Chia-pi-kou area are concerned, the minerals formed at higher temperatures are in the ore veins of the apparent lower horizons. The ore minerals are magnetite pyrrhotite, wolframite, scheelite, pyrite, chalcopyrite, galena, marcasite, gold, hematite, and bismuthinite; the gangue minerals are quartz, sericite, calcite, siderite, and chlorite. The crystallization of quartz and calcite obviously took place during more than two periods. Some quartz has penetrated through the dikes that dissected the ore veins. Calcite is found for the most part at the tapering portion o the veins.

Quartz No. 1: The major part of the quartz belongs to this type. It is white and massive, and the brecciated portion has been mineralized to form the rich ore.

Siderite: The siderite had a very long period of crystallization. It started crystallizing in the early period and was accompanied by the chalcopyrite of a later period.

Scheelite: The scheelite is deep orange-yellow and is found as pockets or stringers in quartz veins. It is crossed by stringers of quartz-siderite-pyrite, and in places shows a crystallization contemporaneous with grayish calcite.

Wolframite: According to Hotta, rich ore of wolframite is rarely found. It forms deep brownish tabular crystals. He reported that it shows a reflection color similar to that of magnetite, has a very low hardness and polarization colors. It may represent the earliest stage of crystallization of all metallic minerals and may be nearly comparable to pyrite. The fissures of wolframite are often filled with stringers of chalcopyrite-gold-bismuthinite-galena-quartz, and the surface is often crusted with bismuthinite, according to Hotta. Manganese is detected rarely in qualitative analyses, so the mineral may be ferberitic wolframite.

Of the tungsten-minerals, scheelite often accompanies calcite, and wolframite is associated with pyrite.

Scheelite may be a little earlier than wolframite in the period of crystallization.

Calcite No. 1: This is the calcite of the earlier stage of crystallization. The grayish crystals, 0.5–1.0 mm in size, are found as aggregates and as indistinct veins within the quartz vein or sericitized country rock.

Pyrite: Pyrite is the dominant ore mineral. It is found as aggregates of small individual crystals or in massive form. In addition, it is widespread in the country rock in veinlets of quartz-pyrite-chlorite-sericite. Fairly coarse pyrite crystals, in pieces, 2–3 mm and larger, are often found in the vein of Pa-jen-pan.

Hematite: Only a very minute amount of hematite occurs; it is rarely associated with pyrite.

Magnetite: For the most part magnetite is closely associated with sericite, but it replaces siderite locally along the cleavage.

Sericite: Sericite is closely associated with magnetite, and often forms gray stringers within the quartz.

Calcite No. 2: This calcite is hardly visible to the naked eye. It is associated with aggregates of magnetite-sericite. Elsewhere it is in narrow veins belonging to the later stage of crystallization.

Pyrrhotite: Pyrrhotite is found uniformly but in small amounts, and is always associated with chalcopyrite.

Chalcopyrite: Chalcopyrite is one of the most important ore minerals and ranks next to pyrite in abundance. It was precipitated along the quartz fissures in association with pyrite and siderite and shows no crystal form. It is accompanied by pyrrhotite, or magnetite, or occurs as fissure fillings in the other minerals in association with galena, gold, and bismuthinite.

Galena: It is reported that in the veins of the lower horizon, a minute amount of galena is found, rarely, in fissures of wolframite in association with chalcopyrite and gold. As the veins become stratigraphically higher, the amount of galena increases gradually and may reach 3 per cent, as in the veins of Tung-shan. It is associated with a minute amount of zincblende.

Gold: Gold is present in association with chalcopyrite; it fills the fissures of wolframite or the fissures of quartz. It is found, rarely, in association with magnetite. The gold content is apt to be lower where scheelite is present. However, the exact relationship between these two minerals is not known. The gold content does not increase with an increase in the amount of galena. In general 4–5 gm per ton of gold are present where there is an appreciable amount of chalcopyrite or pyrite.

Bismuthinite: Bismuthinite is hardly discernible under the microscope. In the Wu-lung Mine, Antung Province, a barren quartz vein was found to contain as much as 10 gm of gold per ton where bismuthinite was present. Therefore, an occurrence of bismuthinite in this area would be worthy of notice.

Calcite No. 3: This is the calcite of the last crystallization. It was found by Hotta at only one spot and consists of a white vein formed of an aggregate of microcrystalline calcite. One side of the vein is marked in places with large crystals of colorless, transparent calcite.

Quartz No. 2: The porphyrite, penetrating the lower veins of Li-shan-hsien, is traversed by quartz veinlets, parallel with the principal ore vein near its hanging wall. These consist of gray quartz with a thickness of about 10 cm. No metallic mineral is present.

Marcasite: Marcasite is closely associated with pyrite, and is thought to be a secondary mineral.

Chlorite: Chlorite forms stringers along the fissures of quartz and often has a ribbon-like appearance. Chlorite is often present in the boundaries between quartz and other minerals. The chlorite is generally green, and, rarely, is deep yellowish. It is considered a remnant of the country rock captured in the vein, and is dominated by "dirty" appearing material.

b. Paragenesis

The order of crystallization, as established by surface and underground survey as well as by microscopic studies, is shown in the following list:

Quartz
Siderite
Scheelite
Wolframite
Calcite

Pyrite
Hematite
Magnetite
Sericite
Pyrrhotite
Chalcopyrite
Galena
Gold
Bismuthinite

4. *Conclusion*

Numerous quartz veins have been found in this area. Those veins that are colorless, transparent or white, coarse-grained, and lacking in sulphide are generally barren of gold; the gold is generally associated with sulphide minerals. The deposits which are closely related to the hornfels schlieren that form a roof pendant within the gneiss generally have a high gold content. It was learned that the old prospecting adits were generally driven along the quartz veins within the green country rock.

Locally veins in association with the green dikes were also prospected, but without success.

The trend of the gold-bearing quartz veins, in accord with that of the country rock, is roughly E-W, and the veins dip 20°–30°S.

The principal veins which have been worked are the Tung-to-yao-tzu, Wu-tao-cha, Pa-jen-pan, Li-shan-hsien, Hsia-hsi-tai, and Tung-shan veins, in apparent ascending order. The largest of these is Pa-jen-pan; the richest ones may be Pa-jen-pan and Li-shan-hsien. Pa-jen-pan probably contains wolframite, and Li-shan-hsien, scheelite.

The veins of Hsia-hsi-tai and Tung-shan, the apparent upper veins, contain galena. This may indicate a gradual gradation to low temperature during genesis, in view of the mineral compositions.

B. Lao-chin-chang Mine

1. *General geology*

The following rocks are present in the area:

Hornfels
Metamorphosed porphyrite
Amphibole diorite
Garnet-bearing amphibole schist
Quartz monzonite
Gold-bearing quartz veins and microgranite
Quartz porphyry and felsite
Porphyrite

Gold-bearing quartz veins were intruded into quartz monzonite or were injected as fine veins into the shear zone of the quartz monzonite, which is associated with hornfels, and form a broad silicified belt. They extend for 5 km and have a general northwest strike. The strike shows a degree of deviation at the northwestern part, becoming N20°W at Ta-chin-niu.

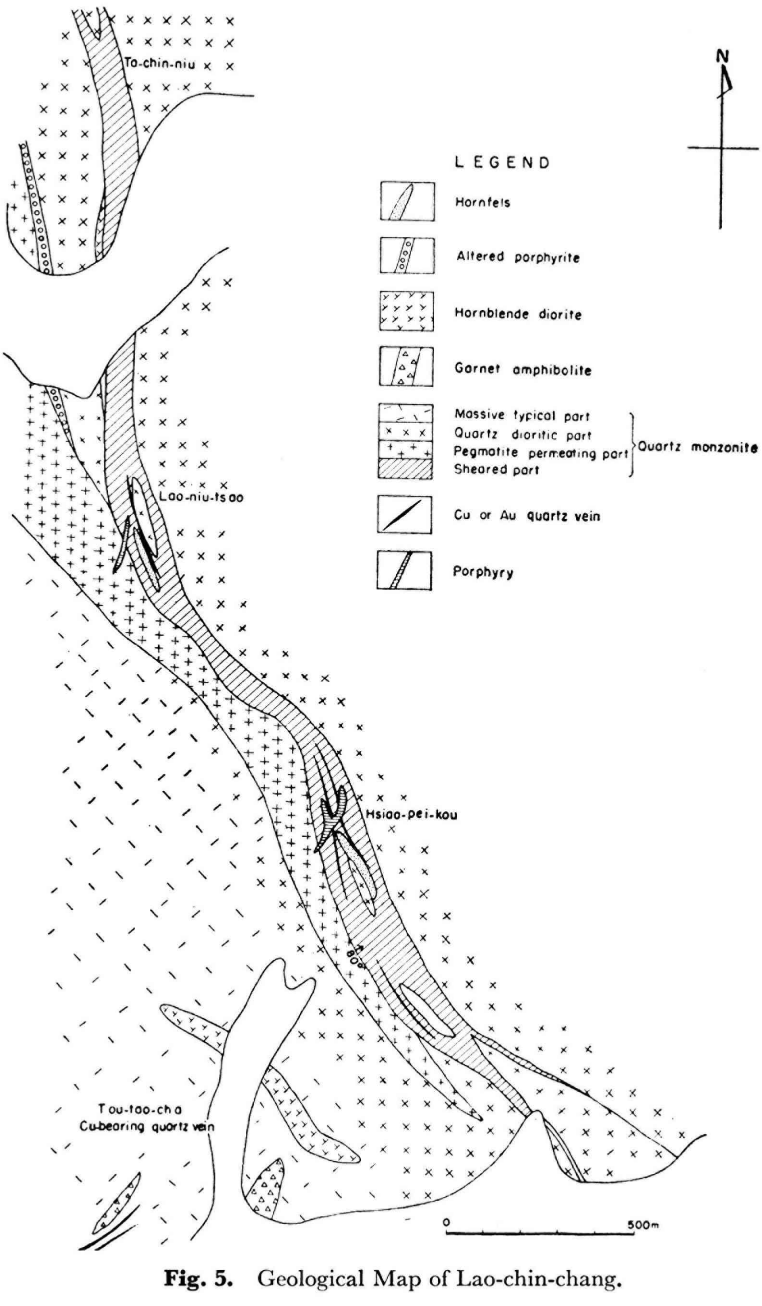

Fig. 5. Geological Map of Lao-chin-chang.

Quartz monzonite is found in the southwestern mountains of the ore deposit zone. It is a massive rock often containing garnet and encloses amphibole diorite and garnet-bearing amphibole schist. At Tou-tao-cha a copper vein of small horizontal extent, with an average thickness of 20–30 cm, has been found within the quartz monzonite. The ore contains 0.6–1.2 per cent copper. The northwestern part of the ore deposit zone consists of a quartz diorite-like rock which encloses thin layers of garnet-bearing amphibolite and large masses of amphibole diorite. The beds have a schistosity which trends N30°–50°W. The quartz monzonite is generally gray, and the quartz in many cases cloudy white, especially in the southwestern masses of the ore deposit zone.

Amphibole schist and diorite may be roof pendants within the monzonite rocks.

A shear zone trending northwest runs along the petrographic boundary of the quartz monzonite rock. It is as broad as 200 m at the southeast part around Hsiao-pei-kou and Lao-niu-kou. In this zone the dark gray portion and the purple schistose rock are finely alternated. They dip 70°–80° NE or are almost vertical.

The shear zone gradually becomes narrower to the north-northwest. At Ta-chin-niu it is 50 m wide. Farther to the north-northwest it finally becomes the schistose rock of both walls of the ore vein.

2. *Ore deposits and ore*

The ore deposits are the silicified part of the brecciated zone and the fissure-filling vein within the shear zone. Quartz veins are often found within the quartz monzonite rocks, but they are almost barren of gold. The only exception is the copper vein worked at Tou-tao-kou.

Quartz monzonite assumes a batholith-like aspect. Its injection may have caused a shear zone along the pre-existing hornfels, and the formation of the ore deposits within this shear zone.

Under the microscope, the twin lamellae of feldspar are seen to be very strongly curved, showing that the quartz monzonite was subjected to crushing.

Gold is associated with the portions containing minute crystals of pyrite and chalcopyrite. Underground samples were taken of the vein at Ta-chin-niu in portions where sulphide was present and where it was absent. Where sulphide was present the gold content was found to be 19 gm per ton whereas only a trace of gold was found where no sulphide was present.

The most prominent deposit consists of the veins of Hsiao-pei-kou near the southeastern end of the shear zone. There are several parallel veins here which are joined together in part. Generally they are narrow, about 0.5 m, at the west side. But to the east the deposit occupies the silicified zone itself and has a thickness of 8 m and a gold content of 5–12 gm per ton. This prominent portion extends for a distance of 200–250 m. The thickness tends to decrease towards the north and downward. However, an extension of the vein is found at Lao-niu-kou, which is about one km northwest of Hsiao-pei-kou, and the vein extends discontinuously within the shear zone from there through Ta-chin-niu and farther to the north-northwest.

The vein gradually becomes smaller, and near the end the mean thickness is 0.6–0.7 m. The ore grade is also less in this portion.

Siderite is found at the ends of the ore vein at Ta-chin-niu and Hsiao-pei-kou, and injection calcite occurs along the schistosity of the schist at the tapering point of the quartz vein. Along the cleavage planes siderite is injected with fine crystals of magnetite.

The fissures and walls of the vein frequently contain chlorite. The mineral composition of the ore is generally simple and so the ore is well suited to processing by the flotation method.

The principal ore minerals are pyrite and chalcopyrite; no galena and zincblende are visible. The veinstone consists mainly of quartz but also contains calcite and chlorite. Magnetite and siderite are considered gangue minerals, and the sheared schist that is intermingled with the ore of Hsiao-pei-kou is also gangue.

The gold content of the ore varies from 5 to 30 gm per ton; the average of the ore feeding to the milling plant is around 6 gm per ton for a monthly feed of 5,000 tons.

3. *Conclusion*

The deposit of Lao-chin-chang is believed to have been formed by the injection of mineral solution into the shear zone which was formed along with hornfels by the intrusion of quartz monzonite. Fine grains of pyrite and chalcopyrite are the principal indices of the gold ore, as a rule.

The gold content of the crude ore is 6 gm per ton, but the ore-bearing zone extends for a very long distance, nearly 5 km, and trends northwest. In addition, there are many old placer gold mines and old gold-quartz mines in the adjacent areas. Therefore, the mine is worthy of notice in conjunction with the Chia-pi-kou Gold Mine.

REFERENCES

KADOKURA, M. (1933): The gold mining industry of Manchoukuo. *Jour. Mining Assn. Japan*, vol. 49, no. 578.

—— (1935): History and present situation of the Chia-pi-kou Gold Mine, Chilin. *Jour. Mining Assn. Japan*, vol. 51, no. 599.

UCHINO, T. (1938): Gold ore deposits in Manchuria. *Jour. Geol. Soc. Tokyo*, vol. 50, no. 593.

HOTTA, M. (1941): Geology and ore deposits of the Chia-pi-kou and Lao-chin-chang Gold Mine, Manchoukuo. Grad. thesis, Tokyo Imp. Univ.

—— (1942): Geology and ore deposit of the Chia-pi-kou Gold Mine, Manchoukuo. *Jour. Geol. Soc. Tokyo*, vol. 49, no. 583.

OGURA, T. (1944): Metallic ore deposit in Manchuria—an appendage to Metallic Ore Deposits in Japan.