

GUIDE-BOOK

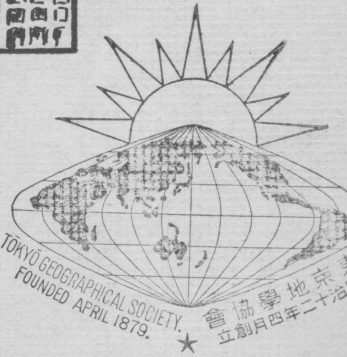
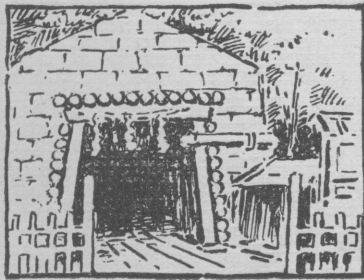
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# THE ASHIO COPPER MINE



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# ASHIO COPPER MINE

## GUIDE TO THE ASHIO COPPER MINE

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#### TRIP TO THE MINE

Visitors leave Uyeno station, Tokyo, early in the morning, sighting from the train window to the left-hand side the continuation of the elevation of Uyeno Park, closely bordering on the railway. The elevation is a margin of the high plain consisting of Diluvium, in which at the cutting of the Tabata station were once found fossils of *Elephas namadicus* Falc. Passing Akabane station the train crosses the river Sumida. Far in the distance on the left-hand side, we sight the dim profiles of a mountain-range which forms the western rim of the Kwantō plain. The range consists of Palaeozoics, the peaks of the mountains presenting a zigzag aspect, beyond which the shapely summit of Mt. Fuji seems to float in the air.

Running northward travellers by train go through the farm lands of the Kwantō plain, consisting of high Diluvium and low Alluvium.

The plain is one of the most fertile lands in Japan, decorated with the glory of rice fields in the harvest season. Further along after passing Kuribashi station the train crosses the river Tone. This is the greatest of the rivers watering the Kwantō plain; one of its tributaries is the Watarase which flows by the Ashio mine. After crossing the Tone, another range of mountains is sighted on the left-hand side. At the right end of this range there are many volcanic cones known as the Nikkō group. There is another group of volcanic cones toward the left edge of the range. This is the Akagi volcano. The middle part of the range is called the Shimotsuke mountainland and is composed of Palaeozoics, granite and liparite; Ashio constitutes a portion of this land. Toward the right-hand side of the train, away in the distance beyond the Kwantō plain there is visible a mountain of pyramidal form. This is Mt. Tsukuba, which consists of diorite. It towers only 900 m. but it looks boldly conspicuous because it is the one solitary peak in the midst of the broad Kwantō plain. On the summit of that mountain there has been erected a high altitude meteorological observatory.

The train proceeds further northward, reaching Oyama station. Passengers have to change cars here and take the Ryōmō line which steams westward. The Ryōmō line runs along the southern foot of the Shimotsuke mountainland. At Iwafune station, to the right is a stone quarry, which consists of andesite traversing Palaeozoics. Near Sano station may be seen a number of freight cars loaded with lime and limestone taken from the Palaeozoic limestone in the neighbouring districts. Passing Ashikaga, travellers to the Ashio Mine change cars at Kiryū station for the Ashio line.

There are two ways to Kiryū: one is the above mentioned way via Oyama and the other, via Takasaki, is described below. After about an hour's ride from Uyeno, travellers turn their course to the northwestward at Ōmiya station, run along the western margin of the Kwantō plain, again turn to the northeast at Takasaki, and thus reach Kiryū. The grotesque aspect of the dissected volcano of Myōgi and the stable forms of the volcanic cones of Haruna and Akagi may be seen to the left-hand side from the train windows along the Takasaki-Kiryū line.

Kiryū and its environs are noted for silk textiles; travellers will see many textile factories and wide farms planted with mulberry trees, the leaves of which are fed to silkworms. These mulberry

farms extend as far as Nagano Prefecture, which is noted for the best silk products in Japan. The localities the train has just run through constitute the centre of this silk industry.

Travellers progress the northward by the Ashio line. For some time the Akagi volcano stands near to the left, while rightward a Palaeozoic mountainland extends mile after mile. After a while the train enters the valley of the river Watarase, which comes from Ashio and empties into the Tone. Beyond Ōmama station the train steams up along the western side of the narrow valley of the river which runs through the Palaeozoic mountainland. The train goes through a series of tunnels. Passing Gōdo station and going over the bridge, the train takes to the eastern side of the river Watarase. From about this point the geology becomes granite traversing the Palaeozoics, and the valley, more properly the gorge, becomes very narrow and deep. The gorge constitute the outstanding feature of the topography of this district; and the crimson tints of its maples, lend great enchantment to the autumn scenery.

Beyond Haramukō station the geology becomes again Palaeozoic and the valley somewhat opens. Then another bridge is crossed which marks the entrance to the area of the Ashio Mine. The first objects to catch the attention of visitors are the settling ponds on the right-hand side, and the dressing mill on the opposite side facing them. The mountain behind the mill consists of liparite and from about this landpoint originate the ore deposits of the Ashio Mine.

Visitors to the mine leave the train at Tsūdō station in the Ashio mining district, which is situated 632 m. above the sea-level, 106 miles north of Tokyo by railway. At Tsūdō are located the headquarters of the Ashio Mine. The dressing mill and the main adit also called Tsūdō are located here. Visitors first inspect the mill, the details of which will be described later. Then they go to Kakemizu, near Ashio station, which is the centre of the mining camp. On their way there, they pass the town of Ashio which presents a gay appearance at night with its innumerable electric lamps. The electric lighting system in Ashio was the first application of electricity in Japan to such a practical purpose. At first the power was supplied from a hydro-electric power station at Matō in Ashio, which was also the first power station installed in Japan. In the mining, traffic is conducted by electric tram; this was the first electric tramway in this country.

**LOCATION** The Ashio copper mine is in the town of Ashio, Kami-tsuga-gōri, in Tochiki Prefecture. The mine belongs to Furukawa & Co., of which Baron Toranosuke Furukawa is the president. The Company works, beside this Ashio Mine, the Furōkura copper mine, the Ani copper mine, the Nagamatsu copper mine, the Mizusawa copper mine, the Kune copper mine, the Iimori copper mine, the Kawayama copper mine, the Ōshima copper mine, the Kijō gold mine, the Shakanoo colliery, the Shimoyamada colliery, the Yoshima colliery and the Mizushima smelter.

The Ashio Mine is situated near the source of the river Watarase, which is a tributary of the big Tone. The headquarters of the mine are on the northwestern bank of the river Watarase, about 630 m. above the sea-level.

**GEOGRAPHY** The mining district is in a recess in the rugged mountains. The waters of the district flow into the single drainage area of the river Watarase. The source of the Watarase consists of three creeks, the Kuzōgawa, Matsukigawa, and Nitamoto-gawa. After gathering these waters the Watarase runs SSE and comes to Akakura, where it receives the waters of three other creeks, namely, the Kyōkonai and Degawa from the west and the Fukazawa from the east. At Kakemizu, the Watarase further gathers the waters of the Mikouchi and Uchinokomori, both coming from the east, and then bends southwestward. At Tsūdō, the creek Shibukawa comes from the north and near Haramukō, the Watarase meets with the big tributary Kōshinzangawa coming from the NNW.

The main course of the Watarase is an open valley with terraces along the banks, while the tributaries Kōshinzangawa, Shibukawa, Degawa, etc., form deeply eroded valleys whose banks consist of rocky cliffs without any terrace. The mountains of the district present a rugged aspect with their peaks swathed in clouds, measuring some 1,300 m. above the sea-level and about 700 m. from the Watarase riverbed. By the courses of the Degawa, the Kōshinzangawa and the Watarase the mountain block is isolated from the surrounding mountains.

The highest peak of the isolated mountain block is called Bizendate and measures 1,364 m. above the sea-level. This isolated block consists of liparite, while the neighbouring mountains are of Palaeozoics and granite. The isolated liparite contains the main part of the ore deposits of the Ashio Mine.

The town of Ashio is upon the terrace of the Watarase, situated to the south of the isolated mountain block. Tsūdō is the western end of the town, while Kakemizu is its eastern extremity. The towns of Matō and Akakura are also on the terrace of the Watarase, east of the isolated block. Honzan is situated in the valley of the Degawa and Kotaki in the deep gorge of the Kōshinzangawa.

**GEOLOGY** Geologically, Ashio is composed chiefly of liparite and Palaeozoic formations, accompanied by granites, Tertiary sediments and younger deposits.

**Palaeozoics:**—The Palaeozoic which constitutes the basis of the Ashio district is composed of slate, sandstone, quartzite and limestone. The strata strike  $N40^{\circ}-60^{\circ}E$  and are folded. The limestone at the Yamaji quarry near Kiryū, which is the upper part of the Palaeozoic formation in Ashio and the neighbouring region, contains fossils of *Fusulina japonica* Gümbel, etc. And once *Helicoprion cf. bessonowi* Karpinsky was found in it. Though the limestone at Ashio has no fossils, it may be somewhat akin to the limestone at Yamaji which belongs to the Permo-Carboniferous age.

**Granites:**—These rocks traverse the Palaeozoic. Granite, quartz-diorite and quartz-porphry are the chief members. The age of the granites is unknown, but judging by granites in other districts in Japan and their interrelationships, the eruption of the granites in the Ashio district may have happened in the middle or later Mesozoic. Other members of these granites are pegmatite, aplite and quartzdiorite-porphryite. Granite, quartz-diorite and quartz-porphry are exposed to daylight in the mountainland lying between Ashio, Kobugahara and lake Chūzenji; also among the mountains extending between Kotaki, Haramukō and Gōdō. The beautiful white gorge which is sighted from the train window between Gōdō and Haramukō stations, is the granite mountainland of which the writer is now speaking.

Granite exercises contact metamorphic action on the Palaeozoics. Slate sometimes graphitizes as seen near the Tsūdō adit. At other times it is metamorphosed to mica-slate in which sometimes occur dots of cordierite. Alongside the rivers Watarase and Kōshinzangawa there are good exposures of slate containing cordierite. The cordierite takes the form of hexagonal prisms of penetration-trilling. The prism is from  $\frac{1}{2}$  to 1 cm. in diameter, 1 to 2 cm. in length. The cross section of a trilling prism is of the shape of a six petalled flower, and is therefore called in the Japanese language *sakura-ishi*, meaning

“Cherry-stone.” The late Prof. Y. Kikuchi, who made a special study of this particular variety of cordierite, named it “Cerasite,” after its peculiar shape. The thin layer of limestone exposed in the valley of the river Matsuki, north of Akakura, undergoes contact metamorphic action and changes into wollastonite.

Pegmatite and aplite appear as apophyses of the granite and penetrate the Palaeozoic slate, in the valley of the river Kōshinzangawa. Quartz-diorite-porphyrity is a phasis of granite-magma which appears in a small area near the mouth of the Tsūdō adit.

**Liparite:**—In the later Tertiary period, a volcanic eruption destroyed the Palaeozoic rocks and formed a funnel-shaped crater. From this crater an eruption of liparite magma took place forming a volcanic cone. This cone has been eroded and now looks like a volcanic neck. At several points in the innermost interior of the Tsūdō adit and the upper third level of the Jūnen vein remains of wood have been discovered in the form of natural charcoal which was caught by the liparite lava from the surface. For this reason we may assume that the liparite now exposed in Ashio is not confined to the neck but also includes lava flow. The liparite forms the isolated mountain block confined by the rivers Kōshinzangawa, Degawa and Watarase. The liparite has an extensive area on the surface, but contracts like a funnel as it goes downward in the mine. The contact section of liparite with Palaeozoic embraces a great number of Palaeozoic blocks presenting the appearance of breccia.

**Tertiary sediments:**—After the erosion of the liparite volcano, a lake was formed near the place called Funaishi between Kotaki and Honzan. A deposit of loose clay was formed in this lake. Although this deposit is now covered by loam of younger formation, it is still visible along the minor cliffs of the valley. This loose clay deposit contains plant fossils such as *Tilla distant* Nath., *Quercus crispula* Bl., *Quercus grosseserrata* Bl., *Corylus heterophylla* Fisch., etc., from which circumstance it may be concluded that this Tertiary is Pliocene.

**Andesites and loams:**—Finally the youngest geologic formations covering these areas are andesite lavas, volcanic ashes and loams which may have come from the Kōshinzan and the Kesamaru volcanoes. They are Quarternary. Owing to active erosion by the waters of the rivers Kōshinzan, Matsuki and Watarase, the valleys are deeply cut, and the curious phenomenon is presented of the youngest formation remaining only on the high ridges.



## ORE DEPOSITS

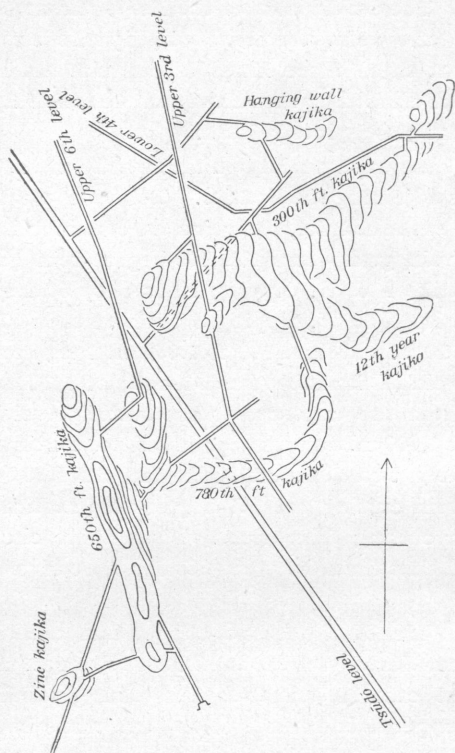
The ore deposits of the Ashio Mine are of three kinds, the vein, the *kajika* in liparite and the *kajika* in Palaeozoic. But these three kinds of deposits are not of different epochs, but were created by the subsequent action of liparite eruption and therefore are closely interrelated.

**Veins:**—These exist mainly in the liparite mass, but run also in the Palaeozoics adjoining the liparite. The veins number over 300 in all. According to their strike, the veins are classified into two groups, the 60-degree-vein group and the 100-degree-vein group. The 60-degree-veins strike N 60°E, dipping N or S by 60 degrees. The 100-degree-veins strike N 80°W, dipping S by more than 60 degrees. The veins are ½ to 10 m. wide and 100 to 1,000 m. long in most cases, but the champion vein (Yokomabu) has a length of 1,700 m. The depth of the veins from the exposure to the bottom level has been ascertained as far as 1,000 m. and it is estimated to continue still deeper. The veins having two different strikes form a sort of lattice work; the 60-degree-vein cutting the 100-degree-vein at times and at other times the latter cutting the former. From these circumstances it is to be concluded that these two vein-fissures were formed at the same time.

The veins are of the quartz-copper and chloritic-clay-copper types, the former developing upward in most cases, the latter downward. In some cases a quartz-copper vein gradually changes to chloritic-clay-copper as it extends downward, while in others one vein consists of the two different types embracing each other, the quartz-copper developing upward, the chloritic-clay-copper developing downward.

The quartz-copper type antedates the chloritic-clay-copper type due to the gradual change of the nature of the mineralizing solution. The quartz-copper vein consists mainly of chalcopyrite, pyrite and pyrrhotite, as well as quartz. The chloritic-clay-copper vein is formed of the same kind of copper ore, but contains chloritic clay as vein stuff and calcite developing downward. Sometimes the quartz-copper vein has a banded structure when the quantity of quartz is ample. The chloritic-clay-copper vein has no definite structure.

The reaction of the mineralizing solution on the country rock is silicification and chloritization in a slight degree when the rock is liparite. But when the rock is quartzite and slate, there is almost no reaction discernible.



**Kajika in liparite:**—The *kajika* in liparite is of an ore-chimney crooked like a serpent. There are five most conspicuous masses; among them, the Kōsei-kajika is the biggest, having an oblong section with diameters of 8 m, and 12 m. and extending 600 m. up and down. The body of the *kajika* consists of sericitic clay and chloritic clay containing chalcopyrite scattered in large and small masses. There is no system in the distribution of the masses. They are discovered haphazardly hidden behind the clay just as bullhead fishes or sculpins are found beneath the pebbles in a river, to which circumstance this type of deposit owes its name of *kajika*, or in English, “bullhead fish” bonanza. The ore of the *kajika* contains almost no pyrite or pyrrhotite. Going upward, the quantity of chalcopyrite diminishes and that of the quartz increases. Sometimes the *kajika* occurs with

connection to other veins. Theoretically, the *kajika* is thought to be formed in the loose textural part of the liparite and to be produced at the moment of the liparite solidification. It is not in the fissure created in liparite afterward. Judging from the fact of the sericitification and chloritification in the *kajika* deposit, its formation must be coeval with the formation of the chloritic-clay-copper vein.

**Kajika in Palaeozoic:**—This exists chiefly in quartzite near the flexure which is folded up like the bottom of a boat, forming huge irregular masses. The *kajika* in quartzite which occur in the Deai district are nine in number. Among them, the Sanbyakushaku-*kajika* (the 300th-ft. bonanza) is the biggest, having 1,500 sq. m. in the cross section at the Tsūdō adit level and 250 m. exploited height. The *kajika* deposits consist mainly of chalcopyrite mixed with pyrrhotite and a small quantity of pyrite. The gangue is of clay which is moderate in quantity. These *kajika* deposits were formed by replacement when the mineralizing solution was in the middle stage of the change from quartz-copper type to chloritic-clay-copper type. This *kajika* has developed tremendously in the quartzite, but in the clayslate split off into small veinlets.

The *kajika* is sometimes found in the Palaeozoic slate. It is a sort of chalcopyrite impregnation. Another type of the *kajika* is found in quartzite, the mineral of which is not of chalcopyrite but of zincblende, and it is called on that account the zinc-*kajika*.

**MINERALOGY** Chalcopyrite:—This is the chief mineral of the ore deposits of the Ashio Mine.

Pyrite and pyrrhotite:—Pyrite occurs with chalcopyrite and is found everywhere. Pyrrhotite is found in the deep parts of the veins and in the *kajika* in quartzite.

Arsenopyrite:—This occurs with chalcopyrite, and is found everywhere, but in small quantities.

Zincblende and galena:—These two are in paragenetic, the former being abundant, while the latter is relatively scarce. These minerals are found only along the margin of the ore deposits. Zincblende is found in small quantities as the last metallic mineral in veins, while in the zinc-*kajika* it occurs very often.

Bismuth and bismuthinite:—These two are in paragenetic and are found in small quantities at several points in the quartz veins and also in the *kajika* in quartzite.

Wolframite :—This is found in limited quantities in the upper portion of some quartz-copper veins.

Secondary minerals :—As secondary products of the metallic minerals, the following minerals occur namely; bornite, chalcosite, cuprite, native copper, malachite, azulite, pisanite, etc.

Quartz :—The main veinstuffs are quartz and clay. The quartz is abundant in the upper section. Amethyst is found, but rarely.

Clay :—Little of this is found in the upper section, but it increases in quantity downward. Commonly this clay is chloritic. In the *kajika* in liparite, sericitic clay is found as well as chloritic clay.

Fluorite :—This is found, though infrequently, in the quartz-copper veins.

Apatite :—This is found in the downward section of the quartz-copper veins and in the *kajika* deposits in the form of small hexagonal plates. The apatite is formed in the last stage of the ore deposit of formation.

Vivianite and ludlamite :—Vivianite is found in the quartz-copper veins and in the *kajika*. The quantity is not large, but the fact that it exists in the form of beautiful crystals deserves special notice. Ludlamite is very rare and occurs accompanied by vivianite.

Calcite :—This is developed in the downward part of the veins, and is the last mineral in the veinstuffs. Its crystal forms are of many different habits.

Gypsum :—This occurs in small quantities as a secondary mineral.

Gold, silver, tin, selenium :—These are found as byproducts of the refinery, but it has not been so far ascertained in what mineral forms they exist.

**HISTORY OF THE MINE** The Ashio Mine was opened toward the end of the 16th century. In 1620 the mine was brought under the direct control of the Tokugawa Government and has since been continuously worked. The Kwan-ei coins imprinted with the ideograph Ashio were made at the Ashio Mines. In 1877 the concession was transferred to Ichibei Furukawa who founded the present Fusukawa & Co. The mine had the reputation of being very rich in copper veins, but during the reign of the Tokugawa Government the sections near the outcrops were practically exhausted. The deeper part of the veins, having been cut off by faults, remained hidden for a long time, and for this reason when the Furukawa firm took over

the mine the annual output did not exceed 500 tons (metric). Ichibei Furukawa made a strenuous effort to find the veins and at last in the Honkuchi tunnel succeeded in discovering the hidden minerals. The opening of the Honzan and the Kotaki adits soon followed. In 1885 the Tsūdō adit was opened on the level 136 m. lower than the Honzan adit. In 1896 these three adits were connected under ground by a system of tunnels and shafts, resulting in the subsequent great prosperity of the Ashio Mine. More recently the mine has been excavated 450 m. lower than the Tsūdō adit. The mine now engages 390 officers and foremen and 3,800 laborers, and produces yearly about 14,000 tons, ranking first in Japan and supplying about one fourth of the total copper production in the country.

**MINING** The main adits of the Ashio Mine are three in number, namely, Tsūdō, Honzan (or Ariki) and Kodaki.

The Tsūdō adit opens on the bank of the river Watarase and is driven in by a crosscut in the northwestern direction, extending 4,000 m. and traversing some 50 veins. Below the Tsūdō adit, there are 12 levels named "The lower 1st," "The lower 2nd" and so on in consecutive order, which are connected with each other by means of 6 blind shafts. The distance between the Tsūdō level and "The lower 12th" measures 450 m. Above Tsūdō there are 17 levels which are named "The upper 1st," "The upper 2nd" and so on in consecutive order. From the Tsūdō level to the upper 17th level, the measurement is 550 m. and each level is traversed by 7 blind shafts. From the upper 17th level upward to the outcrop, there is a distance ranging from 60 m. to 100 m. The upper 4th level which traverses the Yokomabu vein (or the "Champion lode") opens northeast and southwest. The northeast mouth is called the Honzan (or Ariki), while the southwest mouth is the Kodaki. The total distance between the two mouths is 1,800 m. and the level is situated 136 m. higher than the Tsūdō level.

The total number of the veins in the Ashio Mine is more than 300, all intersecting, besides, there are 19 huge *kajika* masses (the "Bullhead-fish" bonanza). The tunnels along the veins run in two directions, N 60°E and N 80°W and meet, forming a sort of rhombus; these are again traversed by crosscuts opened mostly N 20°W. Thus a sort of trigonal lattice work is produced, the tunnels going in three different directions. The same system is repeated on 30 different

levels. We may easily imagine from this something of the complication of the underground geography of the mine.

The mining system is overhand stoping in the case of veins and square-set stoping in the case of *kajika*; the shrinkage system is adopted in the case of the *Kōsei-kajika*. The mining is done by hand drilling with "Ashio-shiki" drills. The total number of the underground workers is 1,700. The ore mined out of various working places is loaded on tubs, whereby it is carried to the shafts and brought to the Tsūdō adit level; it is then transported directly to the dressing mill through the Shinnashi incline near the Tsūdō adit mouth. The transportation on each level is done mainly by hand though gasoline locomotives are also used to some extent. On the Tsūdō and the Honzan-Kodaki adit levels electrical cars are running. There are 10 blind-shafts, all of which are equipped with electric winding engines.

Visitors enter the Tsūdō adit toward  
**GUIDE TO THE UNDERGROUND** N30°W where electric tram cars are running.

The geology of the Tsūdō adit mouth is quartz-diorite-porphyrityrite. Soon we come to the Palaeozoic which forms a synclinal, the axis of which is curved like the keel of a boat, inclining downward from left to right, with the result that Tsūdō adit passes beneath the synclinal strata of quartzite without meeting it. Therefore at Tsūdō only Palaeozoic slate and sandstone are seen. The first object that attracts the attention of visitors is the Shinnashi incline on the left-hand side. On the opposite side will be seen a level branching off to the right. This branch goes along Sanbyakushaku-hi (the 300th-foot-vein); the junction is of slate. As the synclinal axis of the slate inclines downward to the right, the level driven to the right along the 300th-foot-vein will meet the quartzite which constitutes the upper layer of the slate. In this quartzite the 300th-foot-*kajika* bonanza has made a remarkable development by that vein. The huge working place of the *kajika* is visible here.

Coming back to the main adit and going farther NW visitors leave the Palaeozoic and enter the region of liparite. At a distance of about 1,800 m. from the entrance there is the main branch which is called the *Tengu-rōka* along the No. 20 or Tengu vein, belonging to the 100-degree-vein group. Further beyond about 2,900 m. from the entrance the adit reaches the No. 45 or Yokomabu vein which is the champion lode and belongs to the 60-degree-vein group. At this

point there is the Yokomabu 1st shaft. The Yokomabu 2nd shaft is to the right of this, while the Yokomabu 3rd is to the left.

Visitors go along the *Tengu-rōka* which is the left branch of the Tsūdō level. Proceeding on this level they will meet the Kōsei vein belonging to the 60-degree-vein group. The Kōsei 1st shaft, the Kōsei-Maehi shaft and the Kotaki shaft exist here in close proximity. Visitors then go down the Kōsei-Maehi shaft to the 6th level (200 m. below the Tsūdō level) and inspect a vein on the side of the hanging wall of the 6th year's vein striking N 60°E dipping N.

Returning to the main line of the adit, they go to the Yokomabu 2nd shaft. Going 136 m. up this shaft, they reach the Honzan-Kotaki adit level where electric cars are running. Going to the right they reach the Honzan adit mouth. The road going to the left leads to the Kotaki adit mouth.

**DRESSING** The dressing mill at Tsūdō consists of the first plant, the second plant and the zinc ore dressing plant. The mined ore does not go to the Tsūdō adit mouth, but is transported by means of an endless to the mill through the Shinnashi incline.

The ore coming out is classified into the high-grade ore, the low-grade ore, the siliceous ore and waste. The high grade ore comes out in "*kamasu*" or straw-bags. It has an average purity of 12 percent of copper. It is sent to the first plant of the mill where it is dressed by spalling and cobbing. Then it goes directly to the smeltery. The low grade ore and the siliceous ore are brought out in mine trucks and transported to the second plant. Copper in the low grade ore ranges from 1 to 4 per cent. The details of the dressing process are described in the flow-sheet.

The power used in the mill is 900 h.p. The total quantity of raw ore is 950 tons out of which 290 tons of dressed ore averaging 12 percent are produced. The dressed ore is sent to the smeltery by train.

The zinc ore is treated in a special mill, where about 10 tons of ore are daily treated. The zinc ore is not smelted in the Ashio Mine, but is put on the market in the form of dressed ores.

The waste ore is thrown into the damp. The waste water used in the ore mill is mixed with the mine water and put into the settling ponds, where it is neutralized by means of lime. The settled slime is hoisted by dredges and sent to the damp by aerial tramways.





**SMELTING**

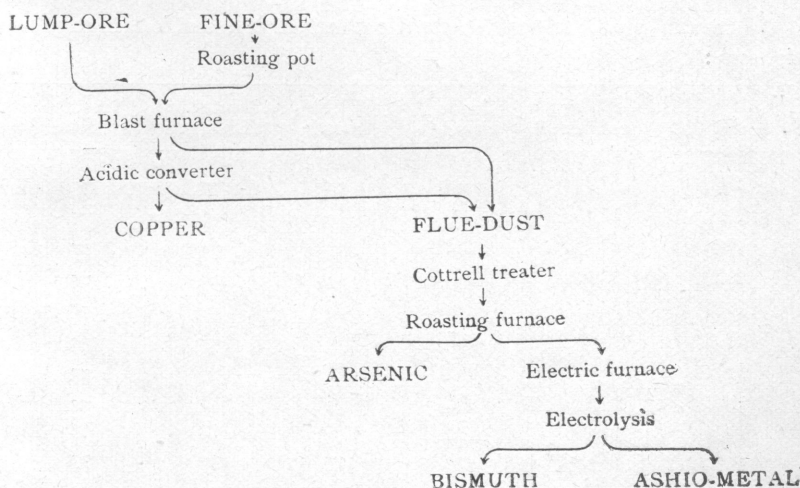
The smelting plant is situated at Honzan. The raw materials are as follows :

Concentrates of the dressing mill:	290 tons a day, average 12% Cu.
Pyrites cinder from Kune Mine :	20 tons, average 6% Cu.
Cement copper :	some.
Scraps, etc.	some.

Besides these, 30 tons of siliceous gold ore from the Handa Mine are used as the lining material of the converters ; 50 tons of limestone, 30 tons of coke and 10 tons of tuyer coal are used. These are transported by train to the ore-bins.

The scheme of the smelting process is as follows :

The fines from the dressing plant are preliminarily treated with the H.H. type pots, twelve in number, whose total capacity is 200 tons a day. The lumps and this pot-roasting product, as well as pyrites, cinders, etc., are charged into the blast furnaces. The furnaces are four in number, of which two are active. Their capacity is 180 tons ore charge a day each. The matt is sent to the Bessemer converters. The slag is granulated by running water and is dumped by aerial tramway at Matsuki, 3 km. off.



The converter stands are four in number. The cell is of the horizontal barrel type and is of the acidic system. The capacity of each converter is 35 tons of matt a day. The working system of the converter is the new so-called "Semi-continuous" in which one third of the copper produced is reserved for the next charge. After four turns of this process, the life of the acid lining is ended, the operation of the cell is then completed and the produced copper is all tilted out.

The blister copper thus produced is cast into anode plates, each weighing  $\frac{1}{5}$  ton. The total daily output of copper is 45 tons, and the annual production is 14,000 tons. The copper is sent to the Nikkō Copper Works belonging to the same company. Analyses (%) of the raw material and the smelter product are shown in annexed table.

The smelter smoke passes through a large flue and chamber into the Cottrell treater. The dust thus caught amounts to 5 tons a day, of which As figures 4 per cent and Bi 1.5 per cent.

This dust is treated in the arsenic plant. Some 3 tons of crude arsenic is thus produced in the arsenic kitchen. The roasted residue is melted in a small electric furnace. The bottom produced in the furnace contains Bi, Pb and Sn. By putting it to electrolysis, metallic bismuth and "Ashio-metal" containing 90% of Pb and 10% of Sn are obtained.

Annual productions (in metric tons) of the Ashio Mine are as follows :

	Blister copper	Crude arsenic	White Arsenic	Metallic Bismuth	Ashio Metal
1916	15,260	—	—	—	—
1917	15,650	—	—	—	—
1918	14,750	52	—	—	—
1919	15,410	650	—	—	—
1920	13,890	820	36	—	—
1921	13,030	887	31	—	—
1922	13,150	1,265	445	—	—
1923	13,540	591	488	0.3	—
1924	14,100	192	473	14	41
1925	13,840	623	343	17	77



**REFINING AND WIRE-DRAWING**

The blister copper of the Ashio Mine is sent to the Nikkō Copper Works and refined electrolytically. The Works are at Kiyotaki near Umagaeshi, Nikkō, and belong to the Furukawa Electric Industry Company, a sister firm of Furukawa & Co. The electrolytic refining plant of the Works consists of two main sections, one the parallel system and the other the series. The refined copper is sent to the melting plant while the noble metals taken out of the copper are sent into the parting plant where they are formed into bullion.

The melting plant has several refractory furnaces producing copper bars. The bars thus produced are sent to the rolling plants and then to the wire drawing mills where they are drawn into wires of all sizes and descriptions. Besides these, strip tape and electro-deposited copper plate are manufactured in these Works. There is also an alloy factory where brass, silicon, bronze, etc., are turned out by electric furnaces. These alloys are used in manufacturing wires, strips, plates and so forth.

The copper wires produced here are sent to the Yokohama Wire and Cable Works owned by the same company, where all descriptions of cables, insulated wires and allied goods are produced.

**FURTHER INFORMATION**

*Power plants* :—Most of the motive power used in the Ashio Mine is electricity. It is generated at the Hosoo hydro-electric power plant which is located near Nikkō and run by the water of the river Daiyagawa which rises from Lake Chūzenji and flows through Nikkō. The power plant belongs to the Furukawa Electric Industry Co. and is about 12 km. northeast of the mine. The power plant comprises three separate power houses. The total combined capacity of the plant is 15,740 K V A. An electric current of 19,000 volts is sent to Ashio, where it is transformed at the three substations at Honzan, Kodaki and Tsūdō. A part of the power generated at Hosoo is sent to the Nikkō Copper Works.

At Tsūdō, Ashio, there is an electric power house equipped with a Diesel engine of 1,200 K V A. This is a spare in case of accident.

*Machine shop* :—The shop is at Matō, Ashio. It takes charge of the repair of the machines and implements used in the Ashio Mine. The machines manufactured as surplus are sold on the public market. The chief manufactures are electric hoists, electric locomotives, motors, transformers, plunger-pumps, turbine-pumps, blowers,

compressors and rock-drills. The rock-drill is a special type improved in the Ashio Mine, and so is called the "*Ashio-shiki*" drill.

*Saw mill*.—The saw mill is situated at Ginzandaira near Kotaki. In the mountain district called Neri behind Ginzandaira, the company owns a very big forestry. The lumber is brought by aerial tramway to the saw mill, where it is shaped into timbers and boards used in the mining work.

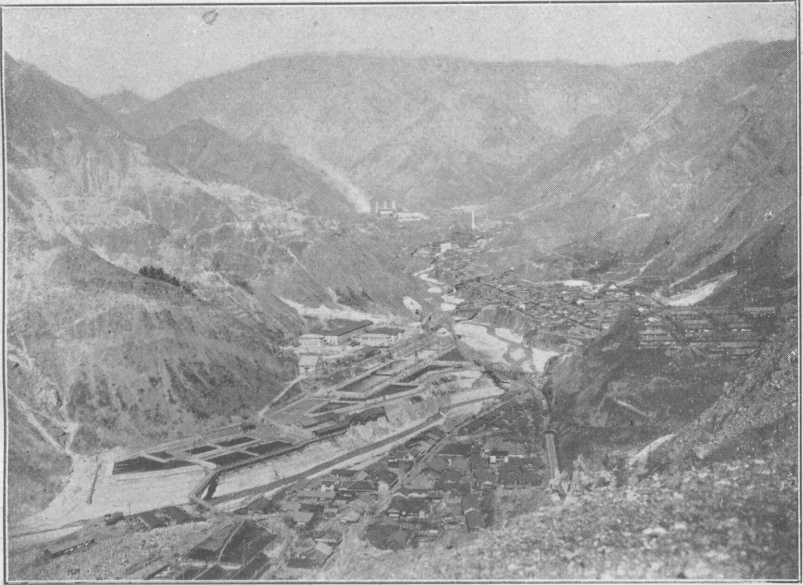
*Smoke problem*.—When formerly the ore was roasted in the stalls in the old fashioned way, the trees on the mountains of Ashio were affected by the fume poison and died. The smoke problem has been successfully solved by the installation of the Cottrell process, but the dead trees had to be supplanted. The company studied this new problem and experimented with cherry trees which they found could best withstand the fumes. The cherry trees in the first group planted on the bank of the river Watarase are now nearly thirty years old, the age for the best floral effect. They have not disappointed the design and the expectation of their patrons. In the season of their bloom, present a score of the most marvellous beauty, attracting thousands of sightseers from localities miles distant and furnishing great consolation to the miners.

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View of the upper course of Watarase-gawa looking northerly.

Honzan  
Smeltery  
Akakura  
Matō



Settling Ponds  
Valley of the Watarase-gawa





General View of Ashio Mine looking northeasterly.

Bizendate Mizuyama

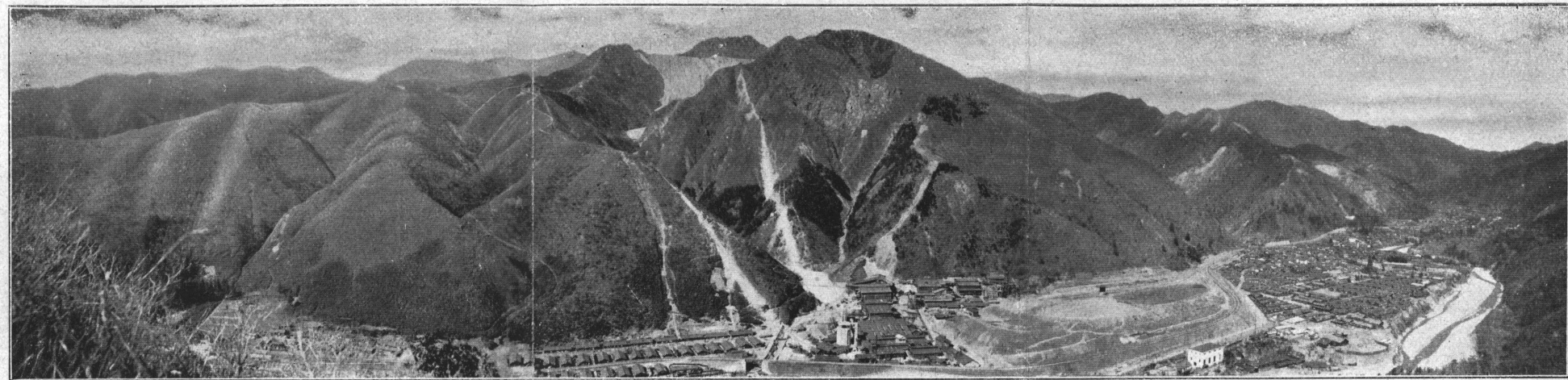


Kōshinzan-gawa

Watarase-gawa

General View of Ashio Mine locking northwesterly.

Waste Dump Mizuyama Honzan



Kōshinzan-gawa

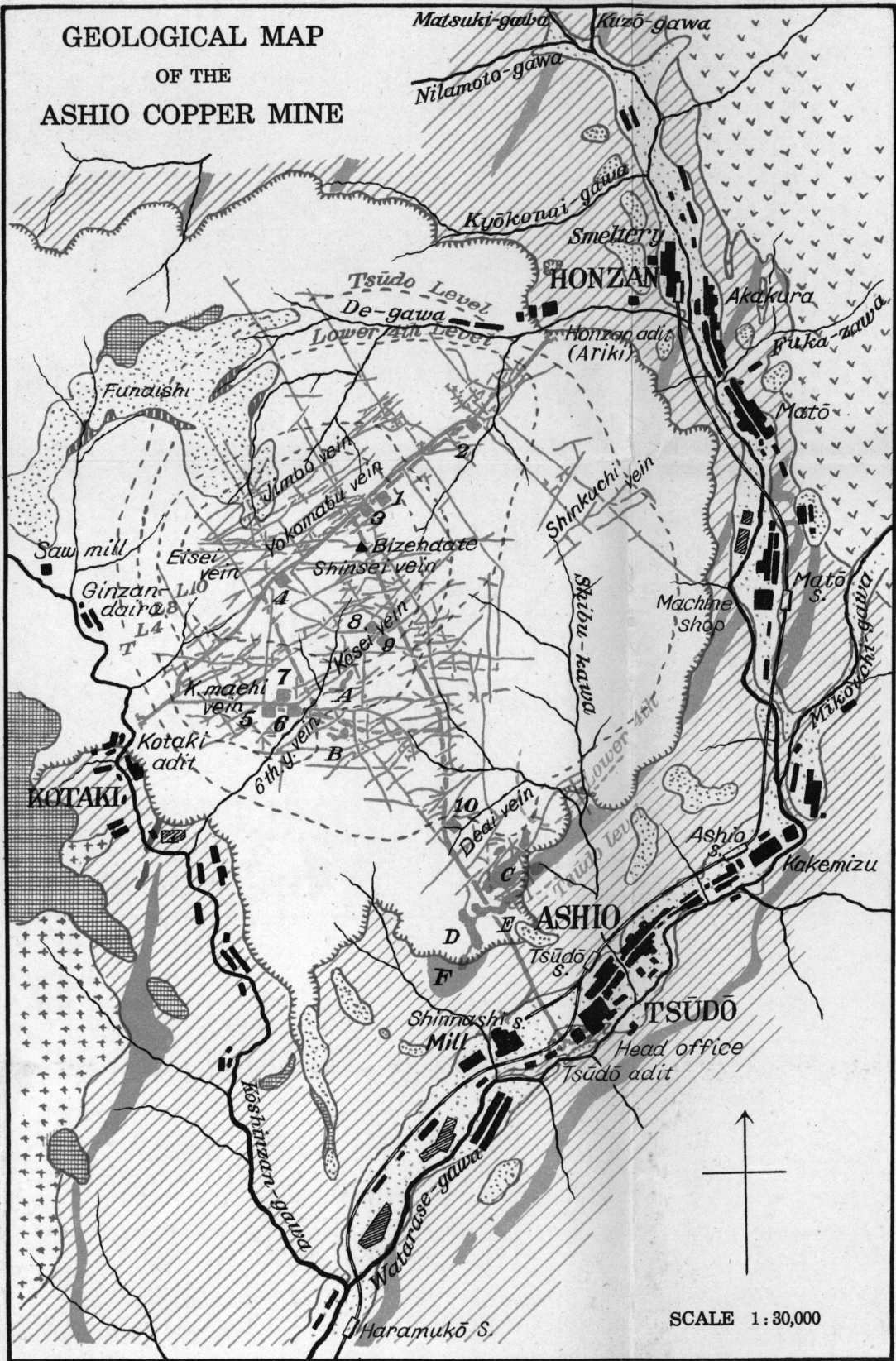
Town of Matō

Dressing Mill

Dump

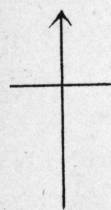
Tsūdō Town of Ashio Kakemizu Valley of the Watarase-gawa

# GEOLOGICAL MAP OF THE ASHIO COPPER MINE

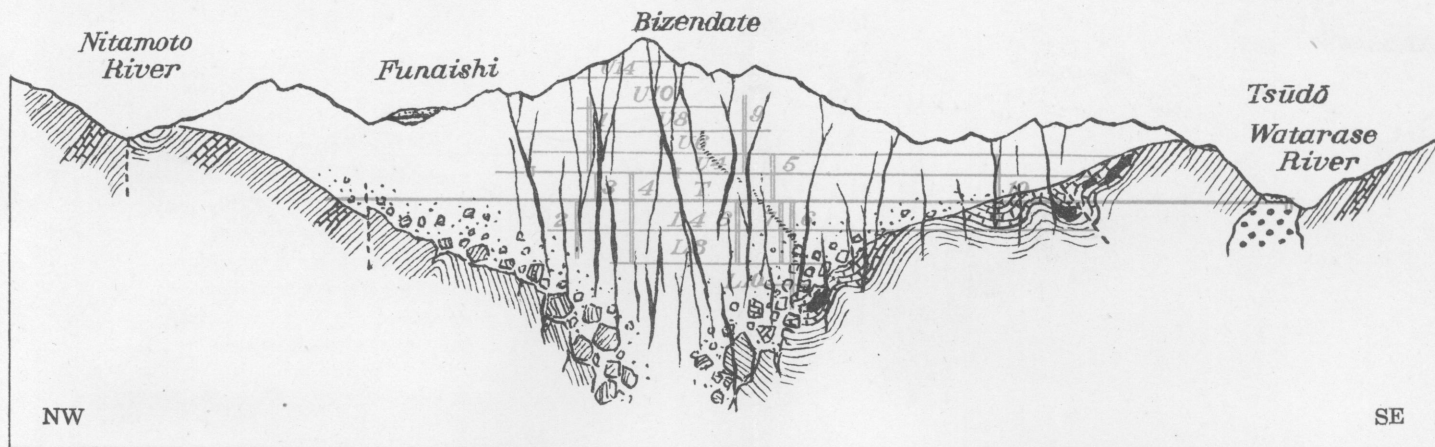


- River-Deposit, Terrace, etc.
- Loam.
- Andesite.
- Tertiary Lake-Deposit.
- Liparite.
- Underground boundary.
- Quartz-diorite-porphyrity.
- Quartz-porphyrity.
- Pegmatite and Aplite.
- Granite.
- Paleozoic Slate and Sandstone.
- Paleozoic Quartzite.
- Underground boundary.
- Adit, Level.
- Shaft.
- "Kajika."

SCALE 1:30,000



- |                          |                          |                          |            |
|--------------------------|--------------------------|--------------------------|------------|
| 1 Honkuchi shaft         | 2 Yokoyama 1st shaft     | 3 Yokomabu 2nd shaft     | Sept. 1926 |
| 4 Yokomabu 3rd shaft     | 5 Kotaki shaft           | 6 Kōsei-Machi shaft      |            |
| 7 Kōsei 1st shaft        | 8 Kōsei 2nd shaft        | 9 Eisei shaft            |            |
| 10 Sunokobashi shaft     |                          |                          |            |
| A Kōsei Kajika           | B Tengu Kajika           | C Deai 300th-foot Kajika |            |
| D Deai 650th-foot Kajika | E Deai 780th-foot Kajika | F Zinc-Kajika            |            |



Palaeozoic  
Quartzite



Slate and  
Sandstone



Q-d-  
porphyrite



Liparite



Tertiary



Loam,  
River-Deposit



Vein



Kajika in  
Quartzite



Kajika in  
Liparite



Level



Shaft

U14 Upper 14th level

U6 Upper 6th level

L4 Lower 4th level

1 Honkuchi shaft

4 Yokomabu 3rd shaft

7 Kōsei 1st shaft

10 Sunokobashi shaft

U10 Upper 10th level

U4 Upper 4th level  
(Honzan-Kotaki level)

L8 Lower 8th level

2 Yokomabu 1st shaft

3 Kotaki shaft

8 Kōsei 2nd shaft

U8 Upper 8th level

T Tsūdō level

L10 Lower 10th level

3 Yokomabu 2nd shaft

6 Kōsei-Machi shaft

9 Eisei shaft

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