# MINING IN JAPAN,

## PAST AND PRESENT.

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# PREFACE.

WHILE the mining industry of Japan, like that in other countries of the world, has a remote origin marked by certain characteristic features, yet its real development was made subsequent to the Restoration of the Meiji period. Among foreigners who are interested in mining, there is no small number who make inquiries regarding the past history and the present condition of mines in Japan. The present work has been compiled for the purpose of meeting the wish for information in the matter. It is hoped that those shortcomings which appear in the work owing to the pressure of time and other causes beyond control, may be rectified in the future.

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# CHAPTER I.

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### SECTION I.

### Before the Restoration.

#### I. FROM REMOTE ANTIQUITY TO 1000 A.D.

At a time of great antiquity when our Yamato tribe had not yet found their way throughout the country, there used to live barbarous tribes of the stone age, whose dwellings were vertical caves covered with roofs of twigs and weeds. In a cave which was lately discovered at the village of Morita, 10 miles west from the port of Aomori, there were found pieces of micaceous iron ore and psilomelane in which holes of an oval shape were pierced from both sides. It appears to us that these ores were regarded as ornaments or curios, without being applied to any practical use.

Of various traditional accounts given in the "Nihonshoki," an ancient history of Japan, there is found one relating to the mining industry. According to this tradition in the mythological age, Amaterasu-Okami (The Sun-Goddess) was armed with swords. It came to pass at one time that she concealed herself in Amano-Iwato (Lit. Heavenly Cave), when several gods were engaged in the act of making contrivances to bring out the Goddess; Ishikoridome, a smith, made a mirror with copper obtained from the Ama-no-Kagoyama, by means of a pair of bellows known as the Ama-no-habuki, which was made of a deer-skin. Susanō-no-Mikoto, the younger brother of Amaterasu-Okami, observed the abundant production of gold and silver in Korea, where his descendants should reign, and urged the necessity of providing themselves with boats to convey them across the sea of Japan. In the course of time he accomplished his object by proceeding to Korea with his son Isotakeru-no-Mikoto. These accounts furnish us with a glimpse of the fact that our ancestors in the prehistoric age knew something about the mining industry.

Records for the space of 860 years from the first year of the Emperor Jimmu (660 B.C.) to the conquest of Korea by the Empress Jingu (200 A.D.), show that swords and mirrors were made early in those days, but nothing definite is given about other facts. When the Empress Jingu conquered Shiragi, a province in Korea, the King promised an annual tribute of eighty vessels loaded with gold, silver, silk, and other treasures, which was followed by the surrender of Koma and Kudara, two provinces in Korea. This state of affairs was conductive to the sudden development of communications between Korea and Japan, as a consequence of which scholars, doctors, and makers of various articles both of utility and artistic merit who brought the Indian civilization with them made their advent in our country from Korea. Thus it came to pass that the knowledge regarding the use of metals was considerably improved by a smith, Takuso by name, who came from Kudara and introduced reforms in the manufacture of metal wares. In the year 370 A.D. during the reign of the Emperor Nintoku, communications with China, supplied our countrymen with a splendid opportunity to bring themselves into a closer contact with various forms of Indian civilization than ever, which soon spread far and wide throughout all quarters of the country. According to the tradition in the reign of the Emperor Kensō (486 A.D.) silver coins are said to have been in circulation, which were not however the product of our country. It was in the year 552 A.D. that the introduction of Buddhism from Kudara (Korea) took place to which form of religion the crown prince Shōtoku became a faithful and enthusiastic convert in 593 A.D., and encouraged its propagation by building numerous temples; as a consequence, there took place a regular influx of carpenters, sculptors, painters, and artists, creating a large demand for metals which was all calculated towards the advancement of the industry. In 668 A.D., petroleum and asphaltic substances were offered to the court of the Emperor Tenji from the province of Echigo, while in 674 A.D., the discovery of silver took place for the first time in the island of Tsushima and the Emperor Tenmu was overjoyed with the discovery that silver was offered to the Shinto deities. The governer of the province was raised to the rank of Shōkinge, and honoured with several favours of particular kinds belonging to that rank. The other officers in the court also participated in the honour and were rewarded according to their merits. In 691 A.D., the fifth year of the Empress Jitō, the governor of Iyo presented silver and its ores from Miumayama, while Kanzei, a Buddhist priest, made a pigment of white lead.

The general tendency of the times showed that the people directed their attention seriously and soberly to the mining industry. Moreover since the beneficient reign of Emperor Monmu, full of sagacity and wisdom, was commenced, and the development of mining industry was encouraged for the interval from 697 to 706 A.D., the records of mineral discovery stand as follows:—

The copper ore from the provinces of Inaba and Suō, alum from Ōmi, antimony and its ore from Iyo; cinnabar, realgar and "Shirome" (a speiss or alloy of antimony, aresenic, zinc, bismuth, tin, and so forth) from Ise; cinnabar from Hitachi, Bizen, Iyo, Hyūga and Bungo; azurite and copper vitriol from Aki and Nagato; orpiment from Shimotsuke; tin from Tanba, and silver from Kii.

The ever-progressive spirit of the Emperor could not be easily satisfied, so that he instructed the authorities of Tsushima to prospect for gold, while Arakawa was ordered to make researches for gold in the province of Mutsu. These endeavours having proved successful, gold was produced in the mines of Tsushima, 701 A.D. This discovery pleased the Emperor to such an extent that he gave the title "Taihō" to the year, which signified "Grand wealth," and by way of commemoration of this discovery, Itsuse, the discoverer, was raised in the official rank, but alas! to the great disappointment of all concerned, the alleged discovery turned out to be a regular fraud. In 699 A.D., the mint was for the first time established, at which copper and silver coins were made. The zeal of the Emperor for mining industry was so intense that he took the initiative for the issuing of the mining law which is known to us in the famous code, "Taihōrei" issued in June, 701 A.D.

The people enjoyed the liberty of mining copper and iron everywhere throughout the country, provided that the government had not the same interests in those districts, but even in the latter cases, mining was allowed to tax-payers.

In case when a discovery of gold, silver or such curious treasures which are likely to turn out to be useful substances is made, an information to the government was to be at once given to that effect.

In 708, the fourth year of the Empress Ganmyō, native copper was presented from the Chichibu County, Musashi. The Empress elated with this happy augury went so far as to change the title of the era to "Wadō" which meant fine copper. The discoverers, Kusakabe-no-Oi, Tsushima-no-Kataiwa, and Konjōmu, were exalted to the honour identical with that of governor of a province, while promotion was extended to the officers concerned. The people of this region were leased from taxation while a general amnesty was granted throughout the country. It was during this year that copper money was made in Ōmi, and in the year following silver coin was issued and was put into actual use along with copper. In 710 A.D., copper money was also made at Dazaifu, Chikuzen. This copper money was now known as "Wadōkaihō" (which meant the treasure made first of fine copper), but only a small amount of the same is extant at present, Fig. 1. Wadōkaihō in full size is given here.


Fig. 1. "Wadōkaihō," in full size.

With the striking increase in the demand for copper, there grew up an urgent necessity for the encouragement of its production so that the system of employing copper as a ransom for crimes was adopted. In "Yōrōrei," a code issued in 718 A.D., by which it was regulated that for capital punishment was to be paid 263 lbs. of copper, for the return from exile 98.6 to 184 lbs., and so forth.

From the geographical records of the provinces called "Fūdoki," which was published in 714 A.D., it was known that Yamato and Mikawa produced mica; Ise, mercury; Sagami, sulphur and alum; Ōmi, magnetite; Mino, Hida, Wakasa, Idzumo, and Sanuki, alum; Shinano, sulphur; Kōtsuke, azurite; and Mutsu, rock crystal, mica and sulphur.

The dissemination of the knowledge regarding minerals brought in its train numerous abuses, as may be inferred from the fact that at Dazaifu, where the mint was situated, the people were prohibited, in 716 A.D., to preserve "Shirome" in their houses as the same was conductive to the production of false coins.

According to a tradition it is said that the discovery of the Ōsaruzawa copper mine, Rikuchu, was made in 714 A.D. Copper was produced from Ushijima, Kumage County and Tariyama, Yoshiki County, Suō in 730 A.D., and since the assaying proved it to be of good quality, it was mined and smelted as the material for the coinage of the mint in Nagato. The mining of copper and iron was freely granted to the people at large by the "Taihōrei" of 701 A.D., but the mines were gradually swallowed up by rich and powerful men as were the iron mines in Ōmi. Thereupon such a practice of monopolization was forbidden so as to give room to the poor for participation in the industry.

The Emperor Shōmu (724—749 A.D.) was a zealous follower of Buddhism and built a large statue of Buddha in a sitting posture in Nara, 745 A.D., whose height was 53.5 feet, for the casting of which fine copper was required to the amount of 488.7 long tons and gold 5,254.4 ounces. Under the circumstances, the Emperor encouraged the discovery and production of the two metals. The copper was chiefly mined from the Tada mine, Settsu; the Akenobe mine, Tajima; the Naganobori mine, Nagato, and elsewhere in Chūgoku. Placer gold was discovered by the governor Kyōfuku, (descendant of the King of Kudara), at Wakuya, 25 miles north-east of Sendai. He made a present of 392 ounces to the government. Konjōmu, discoverer of native copper in Musashi, was a Korean while Kyōfuku, Sumusume and Kōjozan, a smith, who were concerned in the discovery of the placer gold, were also naturalized Koreans or their descendants. Thus we find that our mining industry was greatly indebted to the Koreans.

In 750 A.D. gold was discovered on the coast of Tago, Iohara County in the province of Suruga. The governor and the discoverer were raised in rank and highly rewarded for the contribution they made, and the inhabitants in those districts were exempted from taxes for that year. As several countries north from Taga in Mutsu produced gold, their taxes were paid in 77 ounces of gold in 752 A.D. The Tachibana copper mine, Settsu, turned out to be productive, while in Mimasaka the magnetic sand was dug from pits. Silver and copper coins were extensively circulated in the year 767 A.D., while in 766 A.D. "Shirome" from Hananamiyama, Amada County, Tanba, was presented to the court out of which a mirror was made, and in 770 A.D., sulphur was mined at Yunotaira, Ōnuma County, Iwashiro.

As the knowledge about these metals and the crafts utilizing them became disseminated, gold and silver were held in high esteem as may be seen from the prohibition given to the burial of the two metals with corpses in 646 A.D. The establishment of the mint at the end of the seventh century increased the demand for silver and copper, but as they were used for ornamental purposes, in 815 A.D. a limitation was put upon the use of gold and silver for ornaments, the use of which being restricted to the people in certain ranks while in 834 A.D. the same prohibition was extended to the use of foil and powder of gold and silver through all the ranks of people. The exact amount of the output of gold and silver necessary in those days to meet the demand can not be gauged. The provinces of Mutsu and Shimotsuke produced gold and Tsushima silver, the mine for the latter descending 400 feet below the surface. It happened that in the summer of 864 A.D. it was buried by the heavy rain water. The contrivance of the drainage involved heavy expenses which were not supportable by the miners so that the tax levied was to be appropriated for the purpose of drainage.

According to the "Yengishiki," published in 927 A.D., the products presented to the government from all provinces were as follows:—

Tsushima 1,168 ounces of silver, Shimotsuke 192 ounces of placer gold and 112 ounces of gold bullion, and Mutsu 464 ounces of placer gold. There were, of course, a number of other mines in existence in those days. Records show that in the beginning of the ninth century there were the silver mines of Ikuno, Tajima; Hosokura, Rikuchu; and Gamō, Inaba. In 902 A.D. gold was abundantly produced from Umegashima, Suruga, while in 970 A.D. Kanase Gorō obtained silver from the Tada mine, Settsu, which was presented to his lord, the famous Tada Mitsunaka. In those days gold and mercury formed articles of trade with the Chinese.

Copper and lead were chiefly produced from such provinces as Nagato, Iyo, Chikuzen, Buzen and Hizen in the ninth century. The government worked these mines, and built in 818 A.D. a mint for the coinage of copper money at Nagato. At that time the amount of copper minted was 15.54 long tons and that of lead 7.77 long tons. With the declining production of copper and lead from Nagato, the mint was given up in 868 A.D. But subsequently several mines of Yoshioka, (Bitchu); Okadayama, (Yamashiro); Kafurawariyama and Hichinaiyama, (Mimasaka); Sasayama (Bizen) and Maruyama (Iwami), were opened. The government adopted every possible means for the encouragement of the production of the metals either by the impartation of knowledge concerning the art, or by the remission of taxes, or by the supply of miners and smelters to the required places to open copper mines while the governor of the province was instructed to make a present of a fixed amount of copper or lead ; should he make a present of 1.4 long tons of both copper and lead for three years consecutively he was to be raised in rank. But the supply of these metals was far from meeting the demand. In 940 A.D., the civil war broke out and the coast of the Setouchi Sea (The Inland Sea) was hunted by roving bands of marauders, by whom the mint of Suō was burnt down, which was followed by the suspension of the official mines.

As previously mentioned, the production of iron was made before the eighth century when the provinces of Chūgoku were blessed with an abundant productien of magnetic sand which was obtained from decomposed granite. In 796 A.D., as the production of iron from Bizen was reduced, the payment of taxes in the shape of iron ploughs was stopped. It was at the beginning of the ninth century that famous swords made their appearance in these regions. The necessity of military equipments needed for the provinces in the northern coast of Japan to guard against the invasions which were threatening the country gave birth to fomous sword smiths such as Yasutsuna and his son Sanemori of Ōhara (Hōki), who made sharp swords out of the steel produced in these districts.

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## II. From 1001 to 1582 A.D.

During the last period, the production of gold and silver made a gardual but steady increase, which was particularly the case in the provinces of Mutsu and Dewa. Fujiwara-no-Kiyohira, the hereditary grand lord of these provinces, was very opulent and built in 1124 A.D. the Chūsonji temple, a splendid building of elaborate workmanship at a place near by Hiraidzumi station on the Tokyō- Aomori route. His grandson Hidehira made annually presents of 576 ounces of placer gold to the court. In 1178 A.D., 1,557 ounces of placer gold from the county of Kesen was presented to Taira-no- Shigemori. After the fall of Yasuhira, son of Hidehira, the large estate, belonging to Minamotono-Yoritomo, formed the resources of the Kamakura Shōgunate Government. The rich gold placer was discovered at Shiriuchi, Hokkaidō, during the predominancy of the Shōgun Sanetomo (1205 A.D.) Araki Daigaku, the Lord of Kai, was despatched with eight hundred miners, to prospect the mines and obtained an immense amount of gold. The placer gold in Nishimikawa in the Sado Province was known before 1300 A.D. The Ōmori silver mine, Iwami, was discovered in 1310 A.D. which produced a plenty of silver from the outcrop.

We may gauge from the following historic records that the industry was extraodinarily prosperous from the eleventh to the thirteenth century. In Chapter II, of the Island of Zipangu in "The Travels of Marco Polo," who was the adviser of the Grand Khan Kublai of Yuen, we can find the following passages :—

"They (the Japanese) have gold in the greatest abundance, its sources being inexhaustible, but as the king does not allow of its being exported. Of so great a celebrity was the wealth of this island, that a desire was excited in the breast of the grand Khan Kublai, now reigning, to make a conquest of it, and to annex it to his dominions."

These passages give the real cause of the invasion by the Tartars which was brought to an end by their fatal defeat in 1281 A.D. It is curious to note how the tales of Marco Polo at that time excited the brain of a young Genoan and induced him to the discovery of the New World. Later peace was concluded with the Chinese, with whom Lord Ouchi entered into tradal relations in 1440 A.D. Among the articles of export then made were gold, copper and sulphur. By putting together all those facts, we may obtain a glimpse of the mining industry in those days.

In 1467 A.D., the famous civil war of Ōnin broke out. In the period from that time to the ascendency of Toyotomi Hideyoshi in 1587 the people of the whole country were plunged into the scorching heat of wars, nevertheless the mining industry relating to noble metals was not only fortunately undisturbed but was encouraged by the feudal lords in making provision for their armies. In fact, these mines formed the object of plunder among these warilike tribes. The Ōmori silver mine (Iwami) producing plenty of native silver (1521-1533) offered taxes to Lord Ouchi. The discovery of the Tsurushi silver mine (Sado) together with the gold placer washing of Nishimikawa formed the very coffers of Lord Uyesugi. In 1570 A.D., the Ikuno mine (Tajima) produced an immense quantity of silver which proved to be the rich treasury of Lord Yamana. The Karuizawa silver mine (Iwashiro) was discovered in 1558 A.D., and its subsequent productive activity resulted in the making of an offer of 17,270 ounces of fine silver to the Lord Gamō. In 1528 A.D., gold was produced from the mines of Suruga, out of which gold coins were minted by Lord Imagawa. In 1532—1554 A.D., the Lord Takeda made 143,930 ounces of gold coin which were produced from the mines of Kai and Shinano. These are only parts of the mining industries carried on during the civil war, of which records are extant until the present.

The production of copper from the official mines declined at the middle of the tenth century, and the mint being destroyed by the civil war of Tenkei, the coinage of copper money was suspended, which resulted in the frequent importation from China of the money necessary for circulation by such dignitaries as Shōgun Ashikaga Yoshimasa. These facts, however, do not go to prove the decline of the copper mining industry in those days, since copper was exported by Lord Ōuchi and was also used to make furniture, while the descriptions about the prosperity of copper mines are extensively found at the beginning of the eleventh century. For instance, the copper mines of Nose (Settsu) and Dōgamaru (Iwami) became prolific. The mines of Omodani (Echizen) and Hirayu (Hida) were discovered. The production of the Yoshioka copper mine (Bitchū) was gradually increasing in 1427 A.D.; the Tada mine (Settsu) produced an immense amount of copper in 1570 A.D.; the Ani copper mine (Ugo) was commenced to be mined in 1575 A.D., and the Motoyama mine (Mutsu) was also opened to work about that time. In 1195 A.D., 434.64 long tons of copper were consumed for the purpose of repairing the enormous statue of Buddha in Nara. For the casting of the ponderous bells at Kamakura (Sagami), and Daigo (Yamashiro) 1.21 long tons and 13.47 long tons of copper were used respectively. The Emperor Shirakawa (1072—1128) made as many as thousand statues of Buddha. All these facts confirm us in the belief that copper was abundantly produced in those days.

× It may be interesting to observe that copper metallurgy made a wonderful progress. The method of matte smelting, commonly called the "Mabuki" process or "Yamashitabuki" was invented which is practiced nowadays in small copper mines, where the bessemer process could not profitably be applied, as the cheapest and simplest method of matte smelting. The method was improved since the

Restoration of 1867, increasing its capacity and reducing the amount of the consumption of fuel. This process was invented in the sixteenth century at the smelter of the village of Yamashita, Tada, in the province of Settsu. Formerly the copper matte, produced from the ore smelting was at first roasted and then reduced into crude copper with charcoal in the hearth. According to the new process, the matte, without preparatory roasting, was melted by the charcoal fire, and the iron and the sulphur in it were oxidized with a strong blast, as is the case in the modern bessemer process. The process was conducted in the hearth, in which ore smelting was carried on. The quantity of matte treated at a time was 658 lbs., the charcoal being 30 per cent. of the matte. Being a greater economizer of time and labour than the reduction process, it has been gradually adopted in the western part of our country, which led to the great improvement of the copper industry.

We have but scanty and meagre records of the iron industry during this period. At the Sugatani mine, Iishi county (Idzumo), the smelting plant for magnetic sand was commenced to work in 1266 A.D. The method formerly adopted was a very primitive one which was called "Noro" smelting. A hearth was made in the ground in which magnetic sand was heaped and covered with fuel. When the latter was kindled the magnetic sand grew molten and reduced, leaving the iron mass in the bottom of the hearth. The method of smelting was thus crude, but the art of making sword that was already prosperous in the ninth century, became more perfect than ever, in order to meet the demands of the time. The swords, which were made by Monju in Mutsu, Masatsune in Bizen, Munechika in Kyoto and Okazaki Masamune in Kamakura, form valuable collections of the present days.

Over and above the preceding remarks we have to add the following observations:—The discovery of the Daira lead mine in Ugo took place about 1270 A.D. which was followed by that of the Obira mine, Bungo (1547 A.D.). This mine was started as a tin mine, but was later altered into a copper mine. In 1469 A.D. at Inariyama (Chikugo), a farmer found a coal seam which is worked at present as the Miike colliery, while in 1532 A.D. at Kurobeyama in the province of Etchū, sulphur was discovered and three years later it was worked.

## III. From 1583 to 1867 A.D.

During the period under our consideration the gold and silver mining, which had been encouraged at the earlier periods, made a striking progress; and at the time of Toyotomi Hideyoshi levels of the Hyōtanmabu and the Daidokoromabu of the Tada silver mine, Settsu, were well known for their prosperity. The former derived its name from the fact that Hideyoshi endowed Hara Tanba and Hara Awaji, the heads of miners, with his family ensign of "Sennari-hyōtan" (thousands of gourds) and allowed it to stand at the entrance of the level as a work of the highest honour for its abundant output of gold. The name of "Daidokoro-mabu" (Lit. meaning kitchen), was given because all the household expenses of Toyotomi were met by product from the level. As Hideyoshi became very opulent, he divided 21,588 ounces of gold and 154,713 ounces of silver among his numerous lords in 1585 A.D. In 1587 A.D. he made silver coins, and in the year following gold coins of different denominations were minted.

It came to pass that at this time Kanamori Nagachika, the lord of Hida, ordered his vassal Modzumi Sōtei to made researches for useful ores in his estate and as a result of such efforts in 1589 A.D. he discovered the silver mines of Kamioka and Modzumi, and the Ōtani gold mine. Whence an abundant amount of gold and silver was obtained later on. In 1598, A.D. the discovery of the Osaruzawa gold mine (Rikuchū), was followed by that of the gold mines of Komagi and Gojūmai in the vicinity.

It forms a subject of peculiar interest to observe that Sumitomo Jusai obtained the knowledge concerning the liquation process from an European, who visited Sakai, Idzumi Province. Since then gold and silver were extracted by this process from crude copper at the copper refineries in Ōsaka. The adoption of the new process contributed a great deal to the increase of the output of silver in our country.

The demise of Hideyoshi was followed by the Regency of Tokugawa Iyeyasu who adopted the proposal of Ōkubo Iwami-no-Kami concerning the mining industry. He opened for the first time gold and silver mines in the Idzu Province, at the same time having a control of the Ōmori silver mine (Iwami). In July of 1601 A.D., the gold and silver mine of Aikawa (Sado), which was afferwards known as the Sado mine, was discovered. This mine became conspicuous for the production of an enormous quantity of gold and silver, which was also brought under the control of Ōkubo together with the Tsurushi silver mine and the gold placer of Nishimikawa. Before long these mines were developed to such an extent that they yielded an immense output of these valuable ores. It was during this year that gold and silver currency was coined in abundance. In 1602 A.D., the bonanza of the Waremabu of the Sado mine was prosperous producing 1,199,327 ounces of gold and silver, which fortune was shared by the Kamayamabu level of the Ōmori mine where the silver yielded amounted to 603,946 ounces. Several mines in the Idzu Province became strikingly productive among which we may mention the Nawachi silver mine a particularly conspicuous, since it formed an object of Iyeyasu's pride. At the Ikuno silver mine, the Tsukimabu level was productive in 1585 A.D., which was followed by that of the Sanzensanbyakumai lode in about 1600 A.D. The Osaruzawa gold mine became also productive beginning in the year 1602 A.D. and actually produced 5,277 ounces of gold in 1604 A.D.; this year was blessed by the discovery of the famous Innai silver mine at Ugo.

Notwithstanding the prosperity of the mines and the increased discovery of rich mines as above described, the government did not relax its efforts to develop the mining of these valuable metals, so that in 1606 A.D., Watanabe Bingo was ordered to prospect the gold and silver mines, while in 1627 A.D. "the governors of gold and silver" and "those of gold" were appointed throughout the country for the encouragement of their production.

The mining of the gold and silver mines in those days was only to dig the enriched zone above the drainage level, but as in the course of the operation it became necessary to sink down below the level, the difficulty of drainage was soon felt. In 1607 A.D. the productive capacity of the mines of Sado and Idzu became exceedingly diminished, in all probability on account of water, so that thirty-six mining experts selected from Ōmori mine and the mines of Idzu, were sent to the Sado mine to reform the operation, but in spite of all these efforts the mine was frequently swamped by gushing out of water in the rainy season. In the course of the journey prospecting for noble metals, Ōkubo attempted to work gold placer at Shiriuchi, Hokkaidō, but the effort proved abortive owing to a certain objection raised by Lord Matsumaye Kimihiro.

In 1614 A.D., as the Innai silver mine was troubled by water, the expense for drainage was advanced by the government.

In those days, for the purpose of drainage in the Sado mine a well-bucket only was used which was worked by prisoners convicted

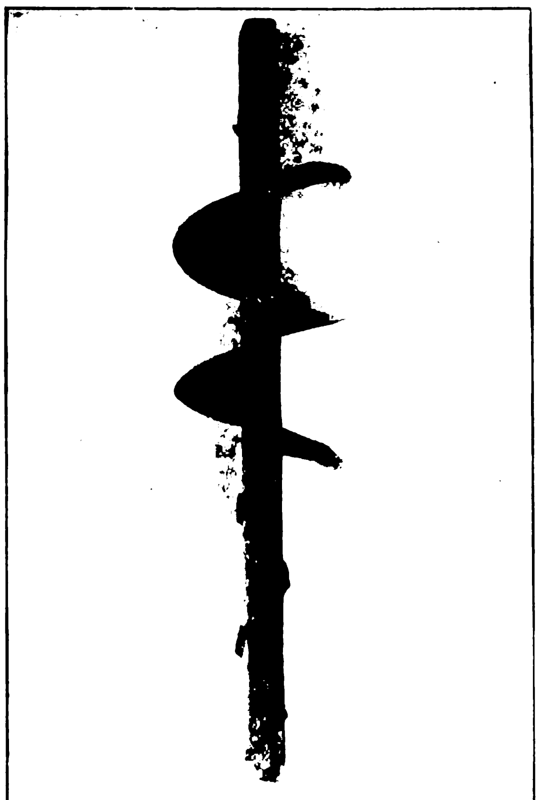


Fig. 2. Screw for "Tatsudoi."

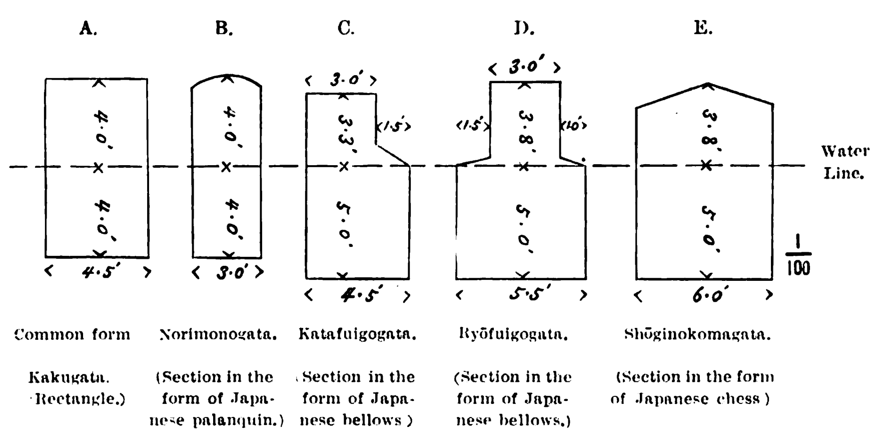
Scale 1/19.

of capital offenses. Since 1634 A.D., the "Supondoi" was adopted, which was a primitive hand pump; it consisted of a wooden pipe 4 inches square and 9 or 12 feet long, having a valve at the point 3 feet below from the upper mouth, and a piston 3 feet long, having a valve at its end. In 1637 A.D., Sōho, the hydraulic engineer, who came from Ōsaka designed the "Tatsudoi" which took the place of the

Supondoi. It was an Archimedean pump consisting of a wooden cylinder and screw, 9 feet in length and 1 foot in the upper and 1.2 feet in the lower diameter. The ruins of such a pumping arrangement were lately found at the old working place, and are now preserved in the Tokyo Imperial University, Fig. 2.

The pumps served their turn well in those days. In 1644, the Ikuno silver mine also declined by reason of the difficulty of drainage. It was at this juncture that Tomomatsu Dōhan mined the levels of Kanaki and Kawato employing some 1,500 persons for pumping, and in the course of two years he earned 35,980 ounces in silver. As the expense of drainage grew enormously heavy in the Sado mine, various taxes were levied from the province in order to make the deficit good. In 1782 A.D., a hand pump was introduced from Holland which was successfully worked at Aoban and Jingo in the Sado mine, saving £707 per annum from the cost of draining. In the year following the above amount of money was used to cut an air way at Seiji level which was abandoned on account of the bad ventilation.

Fig. 3. The Section of the Minazawa Adit.




As the drainage grew to be a serious question for mining the excavation of the adit was started utilizing the topographical conditions. In the Sado mine in 1629 A.D., the excavation of the adit of Midzukane ravine, whose legth was 2,880 feet through andesite tuff was commenced and completed in 1639. In 1647 A.D., the adit of Ōgiri was cut which was completed after the constant work of thirteen years, the length of

FIG. 4. "KUMONOSU-KENGIRI."

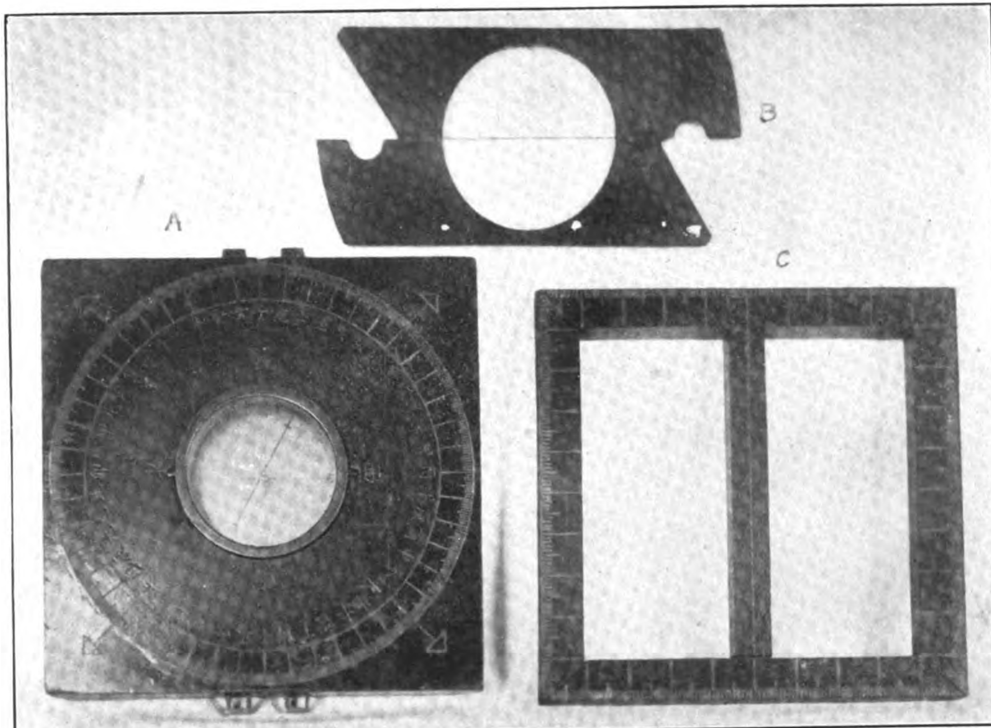
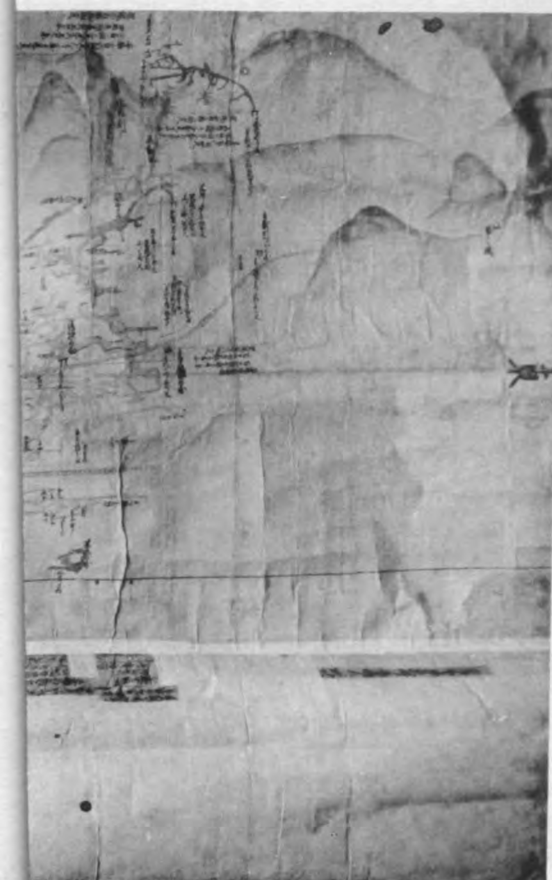



FIG. 5. A. Magnetic Compass.
B. Used in reading the outer graduation being applied on the Compass
C. Clinometer.
Scale $\frac{1}{2}$.



which was 948 feet and that of the accompanying air way 1,080 feet. Lastly the adit of Minamizawa ravine was undertaken which is still extant till this very day. Its excavation was commenced in July 25th, 1691 A.D. to drain the water in the working places at the Waremabu bonanzas. In May 14th, 1696, A.D. success was attained after six years of consecutive efforts the length of the adit was 3,014 feet being excavated from six points, making two intermediate shafts at the Kitazawa ravine. The sections of the adit were made in several forms besides the common rectangular form, in order to reduce the upper pressure and to enlarge the flowing area, Fig 3.

The monthly progress was 8.6 feet through andesite tuff on each attacking face. The excavation was done with chisel and hammer, making the surface of the wall and the roof very even, and leaving the traces of the chisel. A part where the trace resembles the spider's web, is celebrated as the "Kumonosu-Kengiri" shown in Fig. 4. During the excavation the air was ventilated by brattice. The surveyor who acted in this design was Shidzuno Seizaemon who measured with a magnetic compass and clinometer as shown in Fig. 5, which are now preserved at the Tokyo Imperial University. The graduations of the compass are divided into 480 degrees, and each one into 10 minutes, and E and W are oppositely described as the modern compass. The clinometer is one foot square, its graduation being divided into 10 sun and each sun into 10 bu. The progress made in mine surveying in those days may be ascertained by the annexed mine map, Fig 6, which was made in 1695 A.D. and is preserved at the Tokyo Imperial University.

In the Ikuno mine, the adit of Rōmabu was excavated in the year 1608. A.D., and in 1638 A.D. a drainage level was excavated from Takeharano for the whole mine. In 1715 A.D., the adit of Shinkiriyama of the Ōmori silver mine was commenced. At the Handa silver mine an adit was excavated in 1741 A.D., which was completed in 1746 A.D., and resulted in the sudden increase of the output of silver. Latter on, the excavation of other adits was projected in 1786 A.D. In the mines of Tada (Settsu), however owing to the low and hilly topographical condition, adits could not be effectively located so that the drainage was to be performed by manual lalour; consequently if there were rich bonanza, it was next to impossible to work below some horizons, and hence the work had to be given up.

In ancient times, the means of communication being still imperfect, a great deal of difficulty was experienced in the transportation of commodities. As the metal mines were always situated in mountainous regions, the provisions for miners had to be transported from distant places, so that at the outbreak of famines, it was really a serious question how to keep a vast number of working men from starvation. In the famine of 1642 A.D., the Karuizawa silver mine (Iwashiro), had to be abandoned, but the Ikuno mine escaped a similar fate by working the bonanza of Sanzensanbyakumai lode, and in the famine of 1643 A.D., the Sado mine became a great sufferer.

Through the efforts made by Ōkubo Iwami-no-kami for the production of the valuable metals, the mining industry in this country made a rapid and healthy growth. In the Ikuno mine levels turned out to be very prosperous in 1622 A.D., yielding a rich ore of 0.4—0.6% Ag, and the monthly output was 21,588 ounces in silver. The total production of gold in our country in 1630 A.D. was 23,061 ounces, of which 11,889 ounces were from Sado, 9,454 ounces from Satsuma and 1,420 ounces from Idzu. In 1634 A.D., the Nobezawa silver mine, Uzen, became productive, and in these days, there were fifty-three productive levels. The production of 1635 A D. from the Ikuno mine being 143,917 ounces in silver. The Province of Satsuma was known as the chief gold producer from ancient time; in 1638 A.D. the discovery of the famous Yamagano gold mine was made producing 31,380 ounces of gold annually which was followed by another discovery in the well known Serigano gold mine in 1652 A.D. In 1664 A.D., the decline of the Sado mine struck bottom as it yielded only 117,509 ounces of silver, owing to the water trouble at the Waremabu bonanza, and it was finally abandoned. Though the Ikuno mine was thus impoverished in 1644 A.D., yet it was gradually regaining its capacity since 1668 A.D., and in 1671 it was producing 119,932 ounces of silver per annum. In 1669 A.D., the ore of the Osaruzawa gold mine was changed into copper, and it is now being worked as a copper mine. In 1674 A.D. the Waremabu bonanza of the Sado mine was so prosperous that the ore containing 0.29% Ag was extracted and produced 5,037 ounces of silver in ten days. The annual output of that year was described as 239,599 ounces in silver. The Ikuno mine was declining after the prosperity of 1671, but was fortunately checked in its downward course by the flourishing condition of the Ryōgokuyama level. Thus in 1683 and 1696 it produced 42,785 and 122,785 ounces of silver respectively.

In the sixteenth century, the European vessels visited the western shore of Kyūshū, at such places as Hirado, Gotō (Hizen), and Satsuma, and entered into commercial relations with the local authorities. The amount of gold and silver then exported by the Portuguese was enormous. In 1607 A.D., the Dutch ships were granted permission to trade at any ports in our country. After the Christian massacre at Shimabara, 1638, the trade was confined to only the Dutch, Chinese and Koreans at Nagasaki. By the decreased production of silver in our country, its value was exceedingly raised, so that in November of 1662 A.D., the value of one ounce of gold was equal to that of 12 ounces of silver. Thus in order to decrease the amount of silver exported, the gold exportation was granted in 1664 A.D, and the rate of exchange was that one ounce of gold was considered equal to 14 ounces of silver. The amount of silver and gold exported by the Dutch and Chinese vessels during twenty years (1648—1667 A.D.) was 33,222,559 ounces in silver and 55,472 ounces in gold. The outflow of silver was not decreased, so that the exportation of gold and silver was summarily prohibited in 1668 A.D. In 1672 A.D. in trading with the Dutch, the use of gold and silver was permitted owing to the request made by the Dutch on the ground that unless silver were brought to their country from Japan, the price of silver would be raised in Holland causing great difficulty in business. In 1685 A.D., a limit was put upon the total amount of trade to be done, guarding against the reckless export of gold and silver. But the foreigners invited our merchants to private trading on the sea. Thus it will be seen that the exportation of gold and silver could not the altogether stopped. The total amount of gold and silver exported during 164 years from 1601 to 1764 A.D. was 3,763,572 ounces of gold and 135,768,918 ounces of silver. With the diminution of gold and silver currency, commerce in our country was greatly disturbed, and the limited production of those metals from mines was far from satisfying the demand. Hence to increase the amount of currency, the recasting of the old coins, lowing their fineness, was commenced from 1695 A.D. which proved to be a failure as may be seen in the rise of the price of commodities. Under the circumstances, the increase and improvement of coins formed a subject for debate of a serious nature in those days. In August, 1695 A.D., it was declared that, if one found mines of gold, silver or copper, he was at perfect liberty to mine the same at his discretion.

In 1697 A.D., in the Sado mine they began to use stamps driven by water-wheels to crush the poor ores formerly abandoned. The annual output of that mine in 1703 A.D., was 18,788 ounces in gold and 167,636 ounces in silver. The Ikuno mine was prosperous in 1709 A.D. yielding 122,785 ounces of silver. The total output of silver in our country in 1711 A.D. was 479,731 ounces and that of gold 7,533 ounces. In 1715 A.D. rich ores were produced from the Shinkiriyama adit of the Ōmori mine and the output of that year was figured to be 64,503 ounces in silver. In the year following the Sado mine was greatly impoverished producing only 131,802 ounces of silver. In 1767 A.D. the Ikuno mine produced 82,920 ounces in silver.

In 1771 A.D. the Sado mine was not so favourable as it only produced 5,177 ounces in gold and 62,108 ounces in silver. It is very curious to observe that the means of crushing and concentration of ore at that mine was identical with those of Cornwall in old days, as may be seen from the following descriptions: The ore was at first brought into the crushing room (Kanaba), where a slab of andesite was fixed on a base which was 3 feet high and 3 feet wide, at the front of the window. There it was crushed into fines with a hammer, and then was sieved with a fine screen. The fines was introduced into "Tateoke," a dolly tub, with water. After stirring with a ladle, the side of the tub was beaten to settle the deposit. The concentrates were subjected to vanning with a plate vanner. The heading was made into balls and roasted on a charcoal fire. Then the roast was smelted with lead 50% and iron 5%. The lead produced was cupelled, the matte was also smelted into copper, the latter was liquated, and then the lead was also cupelled. The auriferous silver was smelted with sulphur, producing silver sulphide and silver rich in gold. From the former the sulphur was drived and its silver was absorbed in lead, which was then culpelled. The latter was crushed into a fine state, and piled in a conical form on a porcelain basin, being mixed with common salt and roasted. The roast was washed to separate the silver chloride from the gold. The silver chloride was filtered and cupelled. The silver was considered very fine at that time but it contained 0.61% Au. The gold bullion produced contained 99.54% Au.

The production of gold and silver was formerly encouraged, with but little results, Tanuma Mototomo, a favourite of Shōgun Iyeharu, undertook to prospect gold at the Mt Kimbusen in Yamato and Chichibu in Musashi, the former was known as the treasury from ancient times. After continuing effectless working for several years, the work was stopped in 1786 A.D, when the Shōgun died.

In 1804 A.D, the working places of Aoban and Torigoye of the Sado mine were impoverished, reducing the output to 578 ounces in gold and 6,623 ounces in silver. The Yamagano mine, Satsuma, also declined in 1805 A.D. producing only 1,775 ounces in gold annually. The Ikuno mine produced only 33,821 ounces in silver that year, but it was gradually recovering as it produced 85,152 ounces in 1812 A.D. In 1814 A.D. the Ōmori mine became prosperous yielding 27,618 ounces in silver per annum. The Innai mine was productive yielding annually 57,251 ounces in silver from 1741 to 1817 A.D. In 1823 A.D., the Sado mine got some profit after 28 years of loss, but its production did not exceed 1,186 ounces in gold and 30,147 ounces in silver. In 1840 A.D. the production of the Handa mine was increased by draining the water in the Okutate and by the opening of the Nikaimabu. Its output for 146 years from 1717 A.D. was annually 17,037 ounces in silver. In 1861 A.D., the Kosaka silver mine, Rikuchū, which is nowadays the champion mine of copper in Japan, was discovered. After five years Lord Nanbu built a shaft furnace and a cupellation hearth, but the working was disturbed by the civil war of 1867 A.D.

Now the copper industry comes under our observation:—

At the end of the sixteenth century the Kawakami mine (Harima), the Hitachi mine (Hitachi), and the Maruyama mine (Iwami) were prosperous, which was followed by the discovery of the Gamō mine at Iwashiro. In 1610 A.D., the Ashio mine (Shimotsuke), which is now one of the largest mines in our country, was discovered. The Yoshioka mine, Bitchū, was prosperous at that time, yielding 30 long tons annually The Ashio mine was also developed. In 1669 A.D. the Osaruzawa gold mine was changed into a copper mine as mentioned above. In 1670 A.D. the Ani copper mine was discovered. Thus the copper mining industry made a slow, but steady progress.

In the fifteenth century copper was exported by Lord Ōuchi to China, which trading was continuously thriving at the time of the Tokugawa Shogunate. In 1638 A.D. Sumitomo Rihei and twenty-one merchants were granted permission to trade copper with foreigners, thereby the amount of export was greatly increased. But in 1668 A.D. the export of copper was prohibited together with that of gold and silver. Sumitomo Kichizaemon enjoyed the special privilege of exporting copper, since his ancestors have been engaged in the trade since 1573 A.D. At the time under our consideration there were twenty-three copper mines in working order, which after the lapse of seven years, were increased to thirty-four. Of these the Ashio mine stands conspicuous for its prosperity as it produces 1,488 long tons per annum. The total annual production of copper at that time was 5,357 long tons, from which 13,648 ounces of silver was liquated. One-ninth of the copper was consumed at home while the rest was all exported. The labourers in copper mines numbered 200,000 and those engaged in liquation at the copper refineries at Ōsaka 10,000. In 1681 A.D. as the Ashio mine was declining, the capital for recovering was advanced by the government, but the recovery work involved a great amount of difficulty. In 1690 A.D. the engineers of Sumitomo Kichizaemon, who was working the Yoshioka mine, discovered the Besshi copper mine, Iyo, which is one of the largest mines in Japan, and mining was commenced there in the following year under the Government license. It produced 178.5 long tons of copper in the first year, and in 1694 A.D. 595.24 long tons. This year (1690 A.D.) was also made known by the discovery of the Arakawa mine in the province of Ugo. In August, 1695 A.D, the government urged the opening of the copper mines with the mines of gold and silver, to increase their production to satisfy the social demand.

In 1689 A.D. the amount of copper to be traded was fixed, so the Dutch used to have a certain amount of commodities left untraded; in 1689 A D., Fushimiya, a merchant in Nagasaki, applied to the government for the permission to purchase these goods with copper, within a specified limit, which was granted. Thereby the export of copper amounted to 5,298.8 long tons in 1697 A.D., and at home, the supply did not balance the demand. In 1702 A D., the government summoned Sumitomo Kichizaemon to Yedo to undertake the augumentation of the production of the mines of Besshi and Yoshioka, which he was working. Acting under the suggestions of the experienced mine owner, the government advanced five thousand Ryō as a mining capital for the Besshi mine, and the same amount as the funds for the excavation of the adit for the Yoshioka mine; and as the former was located in a mountainous region which was handicapped in communication facilities, 30,914 bushels of rice was granted by the authorities to purchase at nearly one half of the market price; and the products from these mines were extensively exported. It was in this wise that the copper mines of government subsidy were brought into existence, of which the government required a certain fixed amount to be produced for specific objects, leaving any surplus to the disposal of the mine owners.

In 1711 A.D., the total output of copper in our country was 3,809.52 long tons, of which 2,857 long tons were exported. The amount of the exportation was decreased into 2,628.60 long tons in 1715 A.D.: of these exports 1,785.74 long tons were exported to China and 842.60 long tons to Holland. In 1728 A.D. the exported copper amounted to only 758.83 long tons, that is to say, 245.54 long tons from the mines of Akita, 60.36 long tons from those of Nanbu, 395.33 long tons from the Besshi mine and 53.60 long tons from the Yoshioka mine. In March, 1736 A.D., the government urged the starting of the mines of copper, lead or tin, with the purpose of increasing the production, and promised various facilities, as a consequence of which the Kune copper mine (Tōtōmi) in 1731 A.D. and the Kusakura copper mine (Echigo), were discovered.

Copper for exportation was collected by the merchants at Nagasaki, but the amount never came up to that of the demand. Since 1738 A.D., copper was collected at Ōsaka Copper Office and sent to Nagasaki, thus affording every possible facility. In 1754 A.D. the amount of copper for exports supplied from the copper mines under the government subsidies was 1,586.01 long tons, of which 734.27 long tons were contributed from the mines of Akita, 428.81 long tons from those of Nanbu, and 422.94 long tons from the Besshi mine. But later the amount was necessarily cut down owing to the weakened productive capacity of the Akita mine.

The price of copper purchased by the government from the Besshi copper mine was 361 ounces in silver per long ton of copper. In 1750 A.D., it was reduced to 279 ounces in silver, against the market price of 420 ounces. Hence Sumitomo, the owner of the mine, petitioned frequently to raise the purchase price, without avail.

In 1767 A.D., it was raised to 305 ounces is silver, however as our production of copper was scanty, its quotation stood very high. The price of copper for the Chinese trade was 231 ounces in silver per long ton of copper, and that for the Dutch 121 ounces. Hence the copper trade of those times involved heavy losses. Moreover the "Kakeire-dō," (or Lit. Supply copper to fill up the loss of transportation), was added at the rate of one per cent. for Dutch export and one-third of one per cent. for Chinese.

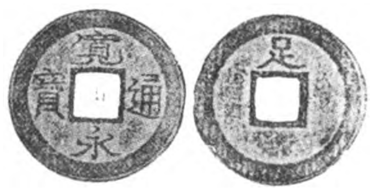


Fig. 7. Copper money, made in the Ashio Copper Mine.

For the space of five years beginning with 1742 A.D., the Ashio mine was authorized to cast a copper money known as "The Kan-yeitsūhō" which was specified with a letter "Ashi" (足), from the name of mine, on the back surface, Fig. 7. In 1747 A.D., the annual output of copper ran to 110.14 long tons. The government lost no energy to bring about the increase of the production of copper and in 1763 A.D. instructions were issued to the effect that copper mines, which had been suspended or left untried, should be thoroughly examined, and that the government should be informed of the results. In 1775, the government itself was going to prospect copper ore at the Mt. Kurama near by Kyōto. Owing to such hard efforts the production of copper was increased while the export of copper was satisfactorily made.

At the end of the eighteenth century, the Daikoku lode of the Omodani copper mine (Echizen), was discovered, which offered to the government 73.8 long tons of copper. It was about the time that the excavation of an adit at the Sasagatani copper mine (Iwami) was started but the attempt ended in a failure not meeting with ore deposits. In 1821 A.D. the Ashio mine had finally to be abandoned, but the Besshi mine was prosperous, yielding, as it did, 400 or 600 long tons of copper per annum, while about 1840 A.D. the Tenwa copper mine (Yamato), and in 1865 A.D. the Hōmanzan copper mine

(Idzumo), were discovered, and almost simultaneously a wide vein was found at the Gamō copper mine, (Inaba), which proved to be quite a prosperous one. In 1860 A.D., the export copper supplied from the copper mines under the government subsidies was 1,086.71 long tons, of which 352.44 long tons were produced from the mines of Akita, 311.32 long tons from those of Nanbu and 422.93 long tons from the Besshi mine. The mines of Tada (Settsu), were productive for 189 years from 1662—1868 A.D., producing 7,152 40 long tons of copper with the exception of eighteen years at the interval during which time the work was given up.

For eighty-five years from 1755 to 1839 A.D. the copper exported by the Dutch vessels was 39,042.80 long tons and that by Chinese vessels was 61,411.87 long tons. For 257 years from the year of the inauguration of the Tokugawa Regency Government (1601 to 1857 A.D.) the total amount of the exported copper was enumerated to be 389,250.25 long tons, that is, the yearly amount of export was 1,514.59 long tons.

The excavation of rocks and ores was formerly effected by means of chisels and hammers, but in the case where rocks and ores were hard, fire setting was sometimes employed as at the Nawachi gold mine, (Idzu), while the same method was applied in the Besshi copper mine to facilitate the mining of the ore. The excavation by such means must have been a matter of slow and tedious work. In 1863, Ōshima Takatō and Pumpelly, an American engineer, introduced for the first time blasting with gunpowder at the Yūrrapu lead mine (Hokkaido).

Iron was formerly smelted from the magnetic sand produced from decomposed granite which occupies the mountainous region of Hōki, Idzumo, Iwami, Bizen,, Bitchū, Bingo and Aki. Owing to the progress of society and the consequent increase of the demand, the iron industry has grown to be quite prosperous. In the valley of the Tōjō river, Bitchū, places worked for magnetic sand numbered 267 in 1671 A.D, from which fact we may draw an inference of its remarkable growth, which must be attributed to the great protection rendered by the feudal lords. It is quite an opportune time to describe the remarkable invention of balanced bellows in Iwami at the beginning of the eighteenth century.

In the iron metallurgy, the tread bellows, "Fumidatara" was formerly used, which required eight men in operation. The newly invented balanced bellows, "Tenbindatara," needed only three men to produce the same effect. The saving of the smelting expense was conductive to the remarkable development of the industry. As a consequence of this growth the conflict of interests with farmers began to arise. For instance, in 1846 A.D., the people in the valley of the Takahashi river, (Bitchū), lodged complaints with the government to stop the washing of magnetic sand on the upper course, because the water of the river became thereby so turbid that it was utterly unfitted for irrigation, and the river bed was raised high by sand deposits, and moreover through the arbitration of Lord Asano, the matter was brought to a successful issue on the ground that the washing was executed during the season when agriculture was inactive. Another industry was soon started in Tosa in 1782 A.D., while the magnetic sand on the coast of the Hokkaidō became the object of attention, and in 1802 A.D., the undertaking towards the smelting of iron was made at the environs of Hakodate, which was not granted by the government. In 1855 A.D. Takenouchi Yasumori and Takeda Hisaburō built shaft furnaces at Kobui, Oshima, Hokkaidō to smelt magnetic sand from the coast, which was the initiative enterprise of the furnace in Japan. The Kamaishi iron mine, Rikuchū, was discovered in 1823 A.D., where the smelting was commenced in 1849 A.D. and in 1860 A.D, shaft furnaces were built by Ōshima Takatō to smelt the iron ores. In 1857 A.D., the Kamiteoka (or Kamichūka) iron mine (Iwaki), was discovered where tread bellows were employed to smelt ores.

In reference to other metals, the want of records prevents us from giving a complete description. Lead was chiefly produced from the silver mines; the total output of this metal was 14 long tons in 1710 A.D. Tin was mainly produced from the Taniyama mine (Satsuma): the output being 76.36 long tons in 1849 A.D., but ten years later it was reduced to 17.62 long tons. Antimony was produced from the Ichinokawa mine, Iyo (1736 A.D.), the same being used for the purpose of drugs and alloy.

Coal in the counties of Onga, Kurate and Kaho (Chikuzen), which are the important coal field in Japan at present, was produced since 1702 A.D in a somewhat limited degree. In 1721 A.D., the coal at Hiranoyama in Miike coal field (Chikugo) was commenced to be worked, which was followed by the discovery of the coal seam in the Yoshinotani colliery, while in 1800 A.D., Goheida, a native of Hirado, discovered the coal on the Takashima (Hizen) and in these districts coal was known as "Goheida" after the name of the discoverer. In those early days, coal was chiefly used for domestic purposes, but sometimes it was sold as a fuel in the salt-works in Inland coast or sometimes it was sold to foreign steamers visiting Nagasaki. It was in 1855 A.D. that a steamship was made a souvenir to the Shōgun by the King of Holland, which suspended the trading in block coal from Chikuzen, since it had to be used as fuel for the steamer. The maximum output of coal from the province of Chikuzen was fixed by Lord Kuroda at 6,000 long tons annually. Coal mining was carried on in those days in so extremely simple a fashion that the hewing was done simply from the outcrop and hence there was every need for improvement. In 1855 A.D., the Ōura slope of the Miike colliery (Chikugo), was started, the length along the slope being 230 feet and the vertical depth 40 feet. The Takashima colliery introduced in 1867 A.D. the European method of mining.

The petroleum in Echigo was formerly obtained from ditches excavated along the outcrop, as seen at Kurokawa, which was, however, changed in 1818 A.D. to the pit sinking method. The utilization of the natural gas from the oil-fields of Garameki village, Kanbara County (Echigo) was projected early in 1613 A.D., drawing but little attention of the people towards the attempt.

At the end of Tokugawa Regency the country was in a troubled condition, whence our mining industry was also disturbed, and at last stopped during the civil war causing the Restoration of 1867 A.D., which has given a happy chance for the mining development.

From the earliest times on record there have been several persons who devoted themselves to the development of the mining industry in our country. Especially Modzumi Sōtei in Hida is worthy of mention since he made great efforts to accelerate the mining industry. Naturally after his death, he was revered and deified by the miners in that region. At the beginning of the Tokugawa Regency Ōkubo-Iwami-no-Kami-Nagayasu exerted himself, as described above, to work the gold and silver mines so as to build up the national resources. When the trade was started with foreigners, an enormous amount of gold and silver was drained off from the country, which reduced the supply at home to such an extent that the scarcity of coins in circulation was keenly felt, while the export of copper was no less large, so that at the end of the seventeenth century the development of the mining industry was the most serious question of the time. At this juncture, the country was blessed by the birth of an engineer at the north-eastern part of Honshū, whose name was Satō Nobukage. He was born at Nishimaonnai, Okatsu County (Ugo), in 1673 A.D., and acquainted himself with the science of administration and agriculture after his father Nobuhide. He opened the Matsuoka silver mine (Ugo), and worked it as was explained in the "Kōjōhōritsu." (The Administration of Mines), 1688—1703 A.D. Later on he mined the tin mine at Ashio, Shimotsuke, 1704—1710 A.D., and the tin mine at Takeda, Bungo, 1716—1731 A.D. He is the author of "Sansōhiroku" (The Principle of the Exploitation of Mines), which contains epitomized accounts of his rich experience. In August, 1731 A.D., at the invitation from one of his pupils he paid a visit to the Ani copper mine in Ugo where in the course of his examination of ores underground gas exploded which ended his glorious and promising career. There are even to these days many miners in the provinces of Mutsu, Dewa, Iyo, Tajima and Iwami who have full confidence in his principle of the exploration of mines. His son Nobusuye was quite epual to his father in point of scholarly attainments, and in 1781 A.D., he prospected the gold mine at Shinjō, (Uzen), and then he visited the Ashio copper mine, where he taught a liquation process. While he was devoting himself to reopen the tin mine which his father had owned, he was affected by the poison from the arsenical fume which proved fatal in 1784 A.D. His son Satō Shinyen was educated by his father, and by celebrated scholars in Yedo in those days and accepting the request of his pupils, he examined the Ani copper mine. Since his scholarly attainments were far in advance of the requirements of the time, he had to retire to Kadzusa from public life in oder to avert the suspicion of the government. Then he devoted himself to reform agricultural science, and wrote sixty volumes on agricultural administration, besides revising his grand father Nobukage's "Sansōhiroku." He wrote also "Kōjōhoritsu," which describes necessary rules for management of mines. He passed away in January 6th, 1850.

## SECTION II.

## After the Restoration.

### I. ADMINISTRATION AND EDUCATION.

Before the Restoration of the present regime, the mining and the metallurgical arts peculiar to Japan developed to the climax which they could have attained without the aids of mechanical contrivance; the only source of power utilizable in that period having been manual labour the progress kept pace with that of Europe, three hundred years ago. If in those days a further progress had been desired, it would have been towards a new direction, based on systematic science and reformed economy. Though some Western technical reforms were apparently introduced during the periods of Tenshō and Genroku (1573—1703 A.D.) and though improvements had been attempted, the industry was rapidly reduced to the most miserable condition about the end of the Tokugawa Government, the consequence was that in Sado, Ikuno and almost all other mines, miners were deprived of the means of living.

The Restoration of 1867 A.D. wrought the greatest change in every direction throughout the country, which was necessitated by the spirit of the times. It was no wonder that the new Government took advantage of that opportunity, and engaged in the encouragement of the mining industry. Thus we find that as the beginning of this policy an act was issued on February 1868 A.D., by which an office, the embryo of the present Bureau of Mines, was established in Osaka, which was formerly called the Ōsaka Copper Office, where copper was to be collected from different parts of our country and refined for the markets. Following this, another act was issued in January, the next year (1869 A.D.) to the effect that mines could be worked in case of application to the local office, if the people in that province did not lodge any complaint. The central government issued instructions to the local government to the effect that permission should be granted to work mines, and that to the people who had worked till then the right of working should be granted whenever the government was apprised of that fact. There followed a series of laws and ordinances, year by year, all aiming at the improvement of the mining industry. Viewed in the light of the present age, the policy then adopted by the government may strike us as having been somewhat ficklesome, nevertheless its main object had been attained at the end.

In order to lead the mining industry into a new channel, new and fresh sources of information must have been sought in the Western countries. Acting upon these convictions our government most wisely utilized the services of mining engineers, civil engineers, geologists, other instructors and even of miners from England, America, France and Germany, numbering in all some seventy-eight men. Seeing the condition of the country in that period, it is astonishing, that the government made such a wise judgment, though a heavy burden to itself.

At this time, the government took up some of the larger mines under its control, and just in time supplied to them knowledge and capital, in which they had been deficient. For this purpose, the Ikuno silver-copper mine in December 1868, and then the Sado gold mine, the Kosaka silver mine, the collieries of Takashima and Miike, the Okudzu gold mine, the Kamaishi iron mine, the Nakakosaka iron mine, the Innai silver mine, and the Ani copper mine—ten mines in all—were selected as government mines suecessively. Among these mines, the foreign engineers were distributed to be engaged in the work; and in oder to prosecute their design, the government invested the necessary capital, and thus it gave the people practical examples of working mines. The people were aroused thereupon from their inactivity in the mining industry. Not only were the mines supplied with capital, but also the people learned the foreign arts which were finally diffused in all the mines throughout the country. Among the eminent mining engineers now engaged in the business, there are not a few who have been directly educated by these Western engineers. The government mines having undergone much reformation, in consequence of the policy above mentioned, the Government afterwards thought it wise to hand over the mines to private enterprise.

Thus all the mines except the Miike colliery, the Ikuno, and the Sado mines, were disposed of to the public. At the same time the engineers who had been educated by the foreign engineers, took the place of the latter in working the mines. Afterwards the Miike was sold to a private operator in 1888 A D., and the two mines of Sado and Ikuno, were assigned to the Imperial estate in the following year, which were, later on handed over to the Mitsubishi Company. Thus it will be seen that at present Akatani iron mine and the Futase colliery belonging to the Yawata Iron Works and three collieries of Shinbaru, Gotoku and Ōmine for the Navy, remain the only mines under government control. In short, the unremitting efforts taken by the government for industrial purposes must have been most appropriate to meet the necessity of the time. Along with those measures, the government did not forget the necessity of educational functions and so an Engineering College, where mining and metallurgical science together with other branches of engineering were to be taught, was established in 1871 A.D. In 1877 A,D., course of mining and metallurgy was commenced in the Tokyo University. Though these institutions supplied a considerable number of graduates, the demand from the mines was far from being satisfied and the want has been most keenly felt. So the government as well as the people, recently endeavoured to establish educational organs, the result of which was the opening of the Kyōto Imperial University and the three government technical high schools in Ōsaka, Kumamoto and Sendai. Another mining school is now being built in the City of Akita by the joint efforts of the mine owners and the government, besides one erected near Wakamatsu in Kyūshū by the private enterprise of K. Yasukawa. Lately a course of lectures on mining and metallurgy are in progress of being opened in the Waseda University, founded by Count Ōkuma. The Kōshu-Gakkō or the Foreman's School, in Tokyo, the technical school of Fukuoka Prefecture, etc. are worthy of notice; the first being the oldest school of this class has the largely number of graduates. Also mines such as the Miike colliery and others, where primary mining education is given, have recently increased. Thus in the future a sufficient number of engineers and foremen can be supplied while it is expected that those who are advanced in technical knowledge, may be obtainable at pleasure, and according to the demand.

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## II. MINING AND METALLURGY.

As described in the preceding chapter, the mining works before the Restoration were executed only by manual labour which was carried to such a stage of perfection as could be desired. Especially, during about hundred years from Tenshō to Genroku (1573—1703 A.D.), the arts were greatly advanced. Thus reliable mine plans were prepared water lifting apparatus of different kinds, especially that designed after the principle of the Archimendean screw, was adopted. Ores were broken by stamps and screened by trommels which were both operated by water power.

As regards metallurgical processes, it is to be noted that the method of liquation was used for separating gold and silver from copper, and a method of parting was used for separating silver from argentiferous gold by means of sulphur. In spite of such a few significant improvements, it is only just to observe that the mining industry being founded upon no systematic scientic knowledge, then gradually declined, which necessitated its reformation in the Restoration period.

Let us now take a few glances at the mining methods in vogue before the Restoration. In that period the mines were worked almost always by means of levels driven from the outcrops in the valleys. Drills and hammers were only implements for breaking ground, the softer and richer parts having been taken out. The rooms and roads were generally poorly supported by timbers, sometimes by ore pillars so that only a single body could move in them. And the great obstacles offered by such methods of excavation to transportation, ventilation and drainage were not perceived at all. So for the work of porters, young boys were employed, who were engaged in the risky and troublesome task of crawling out of the mines with ore bags or baskets on their backs, a small quantity, having been conveyed out each time. Of course, there was but an imperfect arrangement for ventilation and consequently the lights used to go out often, much impairing their health and shortening their lives. As a matter of fact they looked thirty years older than they really were. The mine water was lift up by crude bamboo or wooden pumps. In rainy seasons, the water was rapidly increased, but no measure having been taken against such untoward circumstances, the works had to be stopped. This accounts for the fact why there were once so many old abandoned mines in Japan.

The proprietors of mines being busily occupied with the prospect of immediate gains, did not form any plans for taking future circumstances into consideration. This resulted in the rapid decline of mines, and there took place a constant transference of the ownership of mines. Under such circumstances, even good mines could not continue in operation to any great extent, giving rise to the speedy decline of the mine as described before.

In dressing, ores were crushed by hammers, and coarse grains were jigged by baskets, while fine ore was allowed to flow down a sloping surface, called "Nekonagashi." In executing all these works human labour was employed. Gold and silver ores were ground in stone mills and allowed to flow down sloping surfaces involving thereby no small amount of losses. The inferiority of the old methods of dressing have been proved by the fact that from the wastes of old washing works, abundant amounts of gold and silver have been frequently extracted by newly introduced Western processes of metallurgy, as in the Handa and other gold and silver mines.

According to the old methods of metallurgy, gold, silver, copper and lead ores were equally roasted in stone kilns, with wood as fuel. The roasts together with charcoal were smelted in flat concave hearths on the ground, the blast having been furnished from bellows. Gold and silver ores being charged together with lead for smelting, argentiferous lead was obtained, while the rich lead was cupelled for silver. Auriferous and argentiferous copper ores were similarly treated with lead. In a "Nanbandoko," or liquation hearth, argentiferous lead was separated from the copper and the iron, present in the ores were thrown away as dross. In the process of smelting, the useful metals were partly volatilized or deprived off in the dross the losses of this kind having been unavoidable.

The Restoration was the time during which the old state of the mining industry lasting for years was altered. Five years previous to or in 1863 A D., Pumpelly, an American mining engineer, used gunpowder for blasting in the Yūrrap lead mine in the Hokkaidō, the practice being immediately adopted by the Sado mine. In the year of the Restoration (1868 A.D.), gunpowder was for the first time used in the Ikuno copper and silver mine, thus discontinuing the old methods of drilling and fire setting. During the space of 18 year beginning with 1868 A.D. down to 1885 A.D., we were very busy in the introduction of new Western technical knowledge in different directions of the mining industry. Thus the laying of rails both underground and overground, for the use of ore waggons, the sinking of shafts and the driving of levels of the opening of mines, working system—the stoping, the pillar or long wall system—the methods of timbering, the deep boring for exploration, the application of horse, water and steam power, the use of winding engines, pumps and ventilators, ore breakers, dressing apparatus, reverberatory furnaces, blast furnaces, methods of amalgamation and lixiviation of gold, silver and copper ores, methods of assay, and methods of underground survey and mapping are the principal items of information introduced from the foreign countries.

In the coal field in Kyūshū, where at present, 65 per cent of the total Japanese coal output is produced, the Shakano-o colliery led others into the setting up of boilers in 1881. In the Hokkaidō, coal was first worked in 1883, under American engineers. During the period under our consideration, the domestic consumption of coal was quite insignificant. In 1898 A.D., it was firstly exported to a certain place on the Chinese coasts. Subsequently to the Japan-China War with the sudden uprising of various branches of industry, the foundation of the mining industry was soundly laid. Within the following five years down to 1890 A.D., rock drills, dynamite and high explosives came to be used extensively, while effective up-to-date machineries were adopted in rapid succession; these being aerial rope-tramways, Huntington mils, free vanners, and other new dressing maehines together with Piltz furnaces, water jecket furnances, steam boilers of new types, water turbines, etc.

Since the adoption of electricity generated by water power in the Ashio mine in 1889 A.D., mining operators were introduced to the knowledge of great technical and economical advantages, which has greatly accelerated the progress of our mining industry. Since the introduction of the American rope drilling system into the oil fields in Echigo province, the oil industry gained positive economical successes. After 1890 A.D., with the introduction of the Bessemerizing method of copper and the methods of the lixiviation of silver and copper striking results have been produced. Cupreous or non-cupreous pyrites have begun to be used as a sulphur ore, while the residue was utilized as flux in the smelting of acidic copper ores. The demand for the pyrite grew larger with the increased use of phosphate fertilizers in or about

1900 A.D. Custom smelters appeared after 1890 A.D. In fact the mines of Kosaka, Hitachi, Ikuno, Yoshioka, and others have actually begun to make a purchase of ores. Thus it will be seen that the metallic mineral industry has been gradually and vigorously developed upon an independent foundation.

In coal mines, there were laid railways between the collieries in the Hokkaidō, and the Otaru and the Mororan harbours, and the mining railway of Chikuzen, Buzen provinces, etc., introducing thereby altogether a new feature in the coal mining industry.

It was in the year 1897 A.D. that the cyanide process was introduced into the gold mines in Kagoshima, and this method has rapidly been propagated throughout all the gold mines. The mechanical roasting was introduced in the Ashio mine in 1900 A.D. and the Kosaka mine adopted the pyritic smelting method in 1901 A.D. These facts have practically revolutionized the method of copper smelting in Japan. Blast furnances have been gradually enlarged. Thus for instances in the Kanō mine, a furance 65.5′ × 3.3, in Section at the level of the tuyeres is now being used. The collieries of Kyūshū, were gradually deepened while many of the slopes which have been adopted in the same district, attained the depth of several thousand feet, and hence in reference to timbering, transportation and drainage, the slopes have been felt to be uneconomical. To begin with in 1900, A.D., a shaft of 700 feet deep was completed in the Shin-nyū colliery and in 1902 A.D., the famous Manda First shaft, 896 feet deep, was finished in the Miike colliery. Now shafts of about 1000 feet deep are being sunk successively in the Hōjō, Ita and Futase collieries. Those collieries have gradually adopted electric power which took the place of steam boilers in use. Since "Special" pumps were first introduced in a colliery of Kyūshū, they have been adopted in general except in the Miike; though these pumps are uneconomical, yet they satisfied their demand, because water is found in but a small quantity in all Kyūshū collieries. However, since 1900 A.D., other economical pumps have been adopted such as the Evans and other electric pumps. As regards the improvement of the pumping apparatus, Miike is worthy of note. Requiring a great pumping capacity (about 25,000 H.P.), that mine has gone ahead in the matter of new and powerful machineries, and afforded great benefits to other collieries.

Together with this technical progression, the amalgamation of the mining areas and the enlargement of the working plants have also induced the rapid advancement of the coal industry since 1900 A.D.

The iron metallurgy in Japan has very ancient records to show. In the Sanyō and Sanin districts, pig, wrought iron and steel were prepared from magnetic sand to the satisfaction of all the domestic demands. Magnetic sand in decomposed granite widely distributed in the districts was washed and collected in flumes and ditches by water drawn from great distances. The washed sands were then smelted in a special rectangular furnace. However, the great need of labour and the enormous consumption of charcoal, has of necessity caused the smelting to be discontinued. The government started iron works after the Western method in the Kamaishi mine in 1874 A.D. It proved to be a failure. Ever since that time charcoal pigs have been made in Kamaishi, Hitokabe, and the environs of Morioka city. Iron necessary to fill up the deficiency of the domestic production has been imported from abroad. After the Japan-China War the opinion prevailed that an iron work should be established by the government. The government acknowledged this necessity and the Yawata iron works in Kyūshū were opened in 1901 A.D. Since then, the works has gradually been enlarged, which was followed by the erection of one blast furnace in the Sennin mine, for the manufacture of charcoal pigs, while in the Kamaishi mine, the plant was enlarged, and the Siemens-Martin furnaces were built. In 1909 A.D. at the harbour of Mororan, one experimental blast furnace was blown in. Another steel plant is now being built in the same place, under the co-operative efforts of the Hokkaidō colliery and steamship company, and of the two firms of Armstrong and Vickers.

The most noteworthy events in the recent mining world are the open works practiced at the Kosaka massive ore deposits, the utilization of zinc blende, by means of magnetic separation in the Kamioka and the Kanō mines, the adoption of pot roasting in the mines of Hitachi, Ashio, Kamioka, Osaruzawa, Kosaka, Besshi and so on, and finally the practice of the flotation process in the Kamioka for zinc ores.

At present (1908 A.D.) the motive power utilized in all the Japanese mines and collieries has reached 275,477 H.P. including both steam and water powers, but it is a patent fact that there was not a single boiler at the beginning of the Restoration period (1867 A.D.) In 1890 A.D., the total steam and water power did not exceed 5,300

H.P. In future, it is expected that electricity generated by water will be utilized extensively, so that the amount of the motive power will make correspondingly a great increase.

From the short description above given it will be seen that the mining industry before the Restoration was insignificant, even though the mineral products in 1874 were valued at £154,690. Then it has increased its output to £11,638,667 in 1908 A.D. The principal cause, that has brought about such a great prosperity, is found in the fact that the modern civilization of Europe and America was introduced at the time of the Restoration of the present regime with wise judgment and prudent resolution, whilst under the power of administration and education, potential knowledge regarding the mining industry once owned by our ancestors has been awakened, and brought to actuality.

In reporting the results of the judgment of the fifth national exhibition in 1903 A.D., Prof. W. Watanabe, a jury, speak thus: "After all, the reason why our mining industry has made an incomparably rapid progress depends before anything else upon the wise administration of the government; to which may be added the following reasons:—

(1). The establishment of typical mining works by the government, and the introduction of foreign technics, (2). The introduction of education regarding the mining industry with satisfactory results, (3). The handing over of the government mines to private operation, (4). The publication of mining laws to meet the development of the mining industry, (5). The application of electricity generated by water as motive power in mining works."

## III. LEGISLATION.

In describing the legislative measures with regard to mining in Japan, the first thing that demands attention is the right of ownership.

Right of ownership:—There are, generally speaking, three kinds of right of ownership as to mines, these being (1) the system of accession, that is to say, the system of ownership by private individuals; (2) the Domain system, that is to say, the system of

State ownership; (3) the system of concession, that is to say the system of giving concessions on application.

Japan has never adopted the first system; it adhered to the State ownership system from former times and till quite recently, so that when the privilege of working a mine was granted to any private people, this concession was regarded as a favour of the government, and for a certain limited period in return for the payment of royalty. That period as mentioned in the Japanese Mining Law issued in 1873 A.D. was 15 years.

The progress of the times did not allow the continuation of such an arbitrary system, which was moreover calculated to seriously impair the advance of the mining industry. In 1890 A.D. the said law was amended, and with the operation of the new regulations two years later the concession system distinctly establishing the right of permanent working was inaugurated, and thus safeguarded the sound development of the mining industry in Japan. In 1905 A.D. the Mining Law now in force was promulgated, but it was only a rearrangement of the said regulations and no essential alteration thereto.

The Scope of Mining Work and Kinds of Mines:—In the 1st article of the regulations it is provided that mining work means prospecting, permanent working and all works pertaining to them. The inclusion of the work of smelting in mining work proper is a distinct feature of the mining administration of Japan. It is result of long-established usage and is also due to some extent to the convenience it affords to the government over-seers, for smelting has in most cases been combined in Japan and the division of the two was therefore judged troublesome. Moreover smelting under the same treatment as mining were judged to tend to encouraging the mining industry.

Ores as recognized in law are as follows:—Gold (alluvial gold excluded), silver, copper, lead, bismuth, tin (stream tin excluded), antimony, mercury, zinc, iron (magnetic sand excluded), iron pyrites, chromite, manganese, tungsten, molybdenite, arsenic, phosphate, graphite, coal, lignite, petroleum, asphalt, sulphur, and natural gas. Rejected ores and slags are also recognized as ores in law.

The qualification of Mining Concessionaires.—At first a foreigner was disqualified from working a mine and was further prevented from becoming a member of a mining establishment, so that the right of working mines was exclusively reserved for Japanese subjects. In consequence of the amendment of the Mining Regulations in 1900 A.D. a business establishment organized by Japanese or foreigners or by both combined is allowed to work mines, provided such establishment is placed under Japanese laws. This amendment besides conferring a great benefit on foreigners and encouraging the creation of mining establishments organized by foreigners, has proved a means of stimulating the development of the industry.

Prospecting and Permanent Working.—Differing from the examples seen in many Western countries, Japanese law does not recognize the right of the priority of discovery; the right of prospecting is granted to the one who has first applied for it. The reason why this system has been adopted in Japan is because the fact of an alleged discovery is exceedingly difficult to verify, while an accidental discovery has no right to claim any special privilege. The concession of prospecting carries with it a great privilege in Japan for no other person is allowed to apply for the prospecting in the concession conceded to the first applicant for the same metal as that for which the concession was made to that applicant.

The non-recognition of the right of priority of the owner of land in which a discovery is made is derived from the fundamental principle of Japanese legislature, and must be regarded as highly reasonable provision. The period of prospecting is two years and is not allowed to be extended. In contrast to this limitation in the period of the prospecting, no such limit is enforced with regard to permanent working. Both the right of prospecting and the right of permanent working can be sold or bought or assigned, but only the latter can be made an object of hypothecation.

The fact that the concession of working a mine was at first limited to the space of only 15 years, and that this concession was forbidden from being made use of as an object of hypothecation did at one time seriously interfere with the proper development of the industry. The subsequent amendment of the regulations has removed those two grave defects, and to-day concessionaries and capitalists are enabled to invest a large sum in the exploitation of mines.

The Scope of a Mining Concession and the Supervision of the Working:—The scope of a concession is fixed with a definite limit, it being not less than 40.85 acres (50,000 tsubo) for coal and not less than 4.08 acres (5,000 tsubo) for other kinds of minerals, the maximum limit being 816.9 acres (1,000,000 tsubo) in both cases The two extremes have been so determined in order to prevent the appearance of too small concessions on the one hand and the evil of monopoly on the other. However in cases where it is actually necessary for the protection of mining interests or for the combination ofmore than two concession, the maximum limit may exceed 816.9 acres.

In view of the fact that our mine-owners and people are too apt to attend to their own immediate interests at the expense of the permanent interest of the mining industry as a national economy, and that not unfrequently they secure concessions merely with the object of selling them to other people, the government has deemed it advisable to interfere more or less with the mining business. Thus a concessionaire is obliged to forward to the chief of the Mining Inspection Office in whose jurisdiction the concession is situated the working plan he has drawn up, before proceeding to work the concession. Further, the concession may be revoked by the Minister of Agriculture and Commerce in case the working is suspended for more than a year without any valid reason, while he also requires the concessionaire to submit every six month or annually, the plan of the interior of the mine and the mining work showing the existing condition of the working, and also requires him to get his approval whenever a concession is to be amalgamated with another or is to be split up. Lastly, when the location and shape of a concession as represented in the application is discovered to differ from the actual location and shape of the mineral deposits, the minister may order the concessionaire to mark out his concession anew, on pain of revoking the concession if this order is not obeyed.

The Use of Land:—In mining operations involving the use of the surface of land, the interest of a mining concessionaire is often found incompatible with that of the owner of the land. The only way to find a way out of this difficulty is to requisition for the benefit of the concessionaire so much land as is judged necessary for the conduct of his work and to give a suitable compensation for this requisition to the owner of the land. It is to regulate these relations that the exploitation of the natural resources demands that a special chapter be devoted in the existing law to distinctly define the rights of mining concessionaires and of owners of land. According to the provisions therein contained, a concessionaire may use lands belonging to other persons, when necessary for the following purposes :—

1. Boring, opening shafts or tunnels ;
2. Proving depots of store places for ores, earth and stone, explosives, lumber, fire-wood and coal, tailings, slag or ash.
3. Constructing dressing and smelting plants ;
4. Laying or constructing railways, tracks, roads, canals, drains, flumes, ponds and wells, wire-rope ways or conducting wire ;
5. The building and constructing of other works or constructions necessary to mining.

The owner of the land cannot refuse leasing to the mine-owner the land required for making the provision and the mine-owner in return must give to the owner a suitable compensation by way of rent or damages or must deposit security against rent. Further, the mine-owner is obliged, on the request being made by the owner of the land, to purchase the land used by him in mining work for not less than three years. All the disputes between the land-owner and the mine-owner may be submitted to the decision of the chief of the Mining Inspection Office, and when his decision is regarded unsatisfactory by the parties concerned an appeal may be made, in the case of lease and purchase, to the Minister of Agriculture and Commerce or to the Administrative Court in accordance with the merits of the case, and to ordinary courts of law in case of other kinds of disputes.

Mining Police :—From the very nature of the work not only is the risk to life greater to those engaged in it than in ordinary work, but the work may also involve serious injuries to other parties, by causing, for instance, the depression of the surface level of the land situated in the vicinity of the mine or by causing noxious gas or poisonous matters so spread in the surrounding district. It being judged unadvisable to leave the control of all those matters to ordinary police who can not be properly qualified for the task, it is provided that the following matters shall be attended to by the Minister of Agriculture and Commerce and the respective Chiefs of the Mining Inspection Offices :

1. The preservation of safety relating to constructions and works ;

2. The protection of life and public health ;
3. The precaution against dangers the protection of other matters of public welfare.

When and cause of danger or of injury to the public interests in connection with mining is perceived, the Minister of Agriculture and Commerce shall order the concessionaire to remove such a cause, on pain of ordering the suspension of the work or of revoking the concession in case of his disobeying the order. The Minister of Agriculture and Commerce may order the concessionaire to appoint or make a change in the appointment of managers to be in charge of technical matters.

The Ministers of Agriculture and Commerce has further enacted rules relating to the Mining Police, and enforces strict control over such matters as the use of explosives, arrangements for ventilation, underground works construction of chimneys, boilers, mills, smelters, workshops, provisions against accident, etc. The Chief of the Mining Inspection Office sees to the faithful fulfilment of all the point specified in the rules.

Protection of Mine Workers:—In view of various risks to life and health, special provisions besides those mentioned in the Police Rules are in force for extending protection to mine-workers and their families, these provisions being intended to enforce proper restriction as to to the nature of the work, the number of working hours, relief in case of death or injuries sustained in the discharge of duty. Every concessionaire is accordingly ordered to draw up for use in his own particular concession rules relating to workmen, and to submit the draft for the approved of the Chief of the Mining Inspection Office, the object of this official interference being to provide against unreasonable demands, made by the employers on employees. Further, the Minister of Agriculture and Commerce is authorized by means of Departmental Ordinance to place restrictions on the working-hours of general workmen, and on the kind of work that may be imposed on female workers, and on the working hours and kind of work for miners; also to cause the concessionaire to make suitable relief provisions both for workmen and their families when workmen meet death or are disabled in the discharge of their duties. The concessionaire is under an obligation to draw up regular rules to dead with such cases, and to put them in practice with the approval of the Chief of the Mining Inspection Office.

Taxes on Mining:—Formerly the taxes were of two kinds, one on the leases and the other on the product. The former was at the rate of 2 shillings for every 0.41 acres (500 tsubo) of metallic mines (except iron); 1 shilling for every 0.41 acres of iron and non-metallic mines. The other tax was at the rate of 3 to 20 per cent of the value of the output. In 1875 A.D. the tax on the product was abolished to give encouragement to the progress of the industry. But the imposition of a tax according to the extent of the concession was attended by a serious defect, for it induced the concessionaire to minimize the extent of the leases and therefore tended to prevent the proper exploitation of natural resources. By the further amendment, the original method of imposing two kinds of taxes was restored. This restoration of tax on leases was partly effected with the object of restricting the evil of forestallment by speculators, while the tax itself was in conformity with a long-established usage. The tax imposed on leases shall be 7.3d. sen per annum in respect to prospecting and 1s. 2.5d. per annum in respect to permanent working, for each 0.82 acres (1,000 tsubo) and its fraction. The tax on the products shall be one per cent. of the value thereof. With regard to gold, silver, lead and iron, no tax on products will be imposed. The value of the products is determined according to quotations in the principal markets, the selling price in the place being taken in case of the absence of quotations. Those for which the official quotations exist are at present copper, coal and petroleum.

Alluvial Working:—Alluvial working of gold, magnetic sand and stream tin are treated by the laws in a manner somewhat distinct from other kinds of ore; in this case the right of priority is accorded to the owner of land containing those ores. But when the owner does not work the ores he is compelled to grant permission to do so to those who are desirous to wash them. The owner is entitled in that case to exact a suitable amount of royalty. The working is left uninterfered with, excepting some restrictions of the nature of general Police Regulations. In most other respects the provisions of the Mining Law are correspondingly applied to alluvial working.

The Mining Administration.—The Mining Administration necessarily presents special features of its own and is distinct from the administration of other industries. Some of the principal points with which the mining administration deals are:

I.—Matters relating to the registration as the establishment and cancellation of the right, transfer of it, and pecuniary obligation.

1. Matters relating to the granting of permission for prospecting or permanent workings.
2. Matters relating to the annulment of the permission of prospecting or permanent workings.

II.—Matters relating to the supervision of mining work.

1. Matters relating to the working plans.
2. Matters relating to the correct representation of leases and the surveying of the mineral deposits.
2. Matters relating to the amalgamation or splitting up of leases and to their rearrangement.

III.—Matters relating to the mining police.

1. Matters relating to the protection of public interests.
2. Matters relating to the protection of mine-workers.
3. Matters relating to the safety of mines and of architectural constructions therein.

IV.—Matters relating to disputes.

1. Disputes concerning the lease of land required in carrying on mining work.
2. Disputes (first instance) concerning the deposits against rent and damages, price of land, etc. between land-owners and concessionaires.

The officials taking charge of all those affairs must possess technical knowledge bearing on those points and they therefore differ from ordinary administrative officials in the nature of the work they have to discharge.

The mining administration affairs are subdivided into categories, central and local. The former are taken charge of by the Director of the Mining Bureau subject to the control of the Minister of Agriculture and Commerce, while for attending to the latter section of business, the country is subdivided into five divisions, each under a Mining Inspection Office established by the Department of Agriculture and Commerce. The reason why local mining affairs are not left to the control of local administrative offices is because each kind of ore should be placed under a uniform mode of control irrespective of the place of produce and because different treatments by different local offices would only have the effect of preventing the due development of the industry. The Chief of each Mining Inspection Office is the controlling power of all the mining affairs occurring in his jurisdiction, and he deals with them either with the approval of the Minister or on his own responsibility, according to the relative gravity of matters. The administrative business relating to alluvial workings is practically identical with the foregoing, and therefore requires no special description here.

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## IV. CONDITION OF MINE LABOURERS.

The total number of persons employed in Japanese mines was 205,144 in December, 1908 A.D. These include miners, porters, dressing hands, smelting men, engine-drivers, smiths and pumpmen. Most of these labourers work underground and in uncomfortable environments, but in spite of these disadvantages they are generally satisfied with their lot and go to work with light hearts. Some of those labourers are natives of the district in which the mine is situated, but the greater number of them are from other provinces, no small number of whom settle down, form families where they reside until their death. These mine-labourers generally live in dwellings provided by their employers, those with families in separate rooms and those without families in large common rooms.

For the miners, frequently, provisions are supplied by the mine owners, sometimes at a very low price. This institution of a cheap supply of food is adopted with different views. Namely: for the convenience of the labourers when the mines are situated at a distance, for those who can not freely pay money until they receive the account in the day of payment, for checking a rise in the prices of commodities, or lastly for supplying a specially low priced goods.

As mine labourers are encouraged in their work, by various possible means provided by mine owners for the purpose of the acceleration of the work the increase of the output or to promote their income, they are frequently accommodated with certain organs of comforts and amusements in mines and collieries. There are provided tho festials of the mine gods, two or three days in a year, when there are held plays, wrestling or various other entertainments. Sometimes the labourers are treated to "Sake," a Japanese wine, and also in the national festivals or other specified holidays, entertainments are held by mine owners. There are organized memorial services for those who have died violent deaths. Priests are invited by the miners that they may hear their sermons. In some mines such as the Osaruzawa and others, preaching houses or chapels have been specially erected.

In consideration of the great risk to which they are exposed, their employers are bound to take care of them, when they meet with accidents while on duty. The employers bear a part or the whole of the expenses of medical attendance, and when the patients are treated in hospitals other than those owned by the employers, they are daily paid a sum of money to meet the expenses of such hospitals. In case of their being disabled, they are given a fair amount of money, and in case of death, generally the sum of one pound sterling or more is granted to the bereaved families toward the funeral expenses, besides making some allowance to the families.

There exist peculiar usages among miners. When the young-men's ability regarding the practice of drilling and blasting are recognized, they are promoted and enlisted as "miners" with dignified ceremonies in the presence of their own bosses and fellow-workers. The oaths of allegiance to chiefs by proteges and to their bretheren are observed with religious strictness. It is expected that the instructions of the boss are to be obeyed whether they are right or wrong. These chiefs are in intimate communications with one another, so that in case a miner goes from one mine to another, seeking employment, etc., he may rely upon receiving kind treatment if he gives the name of his chief. His new friends will go to no little trouble to find employment for him and will often give him money to cover his travelling expenses. This peculiar spirit of fraternity is utilized for the control of miners; and it is difficult for the outsider to realize how implicitly the commands of these chiefs are obeyed and how well order is preserved. Sometimes these retainers of a boss cause trouble to the latter's employers. Under such circumstances, one would suppose that strikes must be of frequent occurence, but this is not the case. Indeed strikes of miners are almost unheard of. The absence of strikes may generally be ascribed to the kind treatment accorded to miners.

The morality of miners, it must be added, has been long inherited from the "Samurai" spirit of the feudal ages in Japan. Some Samurai, who had been defeated and lost their chiefs, found their way to escape to remote mountainous regions and there discovered ore deposits and worked them for self-supporting. Thus, for an example, a bereaved subject of Konishi Yukinaga in the battle of Sekigahara (1600 A.D.) discovered the Innai ore deposits. Thus mines were worked successively by their sons, grand sons, and their descendants. The villagers or at least those who are directly engaged in underground works were educated by vagrant Samurai or their descendants. They settled down in the mine where their ancestors had lived or worked, or emigrated to other mines to work there. Hence in the age of the Tokugawa Shogunate Government the miners were treated by the Government the same as those of Samurai rank. With the progress of time, the spirit of the Samurai has waned and become weaker. Nevertheless, something has remained in their heads and shows itself in conduct of miners, who only know how to work underground with drills and hammers. Such accounts for the peculiar usages existing among miners even at the present day.

In respectable mines, mine-workers' mutual aid associations are in existence. The aim of these associations is to extend help to the members in case of emergency. To this end, funds are created by contributions from the members, and also from the mine owners or other patrons, and disbursements are made from these funds in case of the injury, illness, or death of any of the members. The sums to be contributed by the mine-labourers vary according to different associations. In some cases, a certain fixed sum is contributed uniformly by all, while in other cases, sums are contributed in proportion to the position of the workmen. Such contributions are made every month out of their incomes. In granting the relief, the amount to be given is fixed, other things being equal according to the length of time the party to be relieved has been a member of the association or according to the position of the recipient, or according to both.

## V. STATISTICS.

### TABLE I.

### Production of Principal Mines in 1908.

### I. MINES OF GOLD, SILVER, COPPER, AND LEAD.

| Mines. | Prefectures. | Concessionaires. | Output. | | | | | No. of Labourers. |
|---|---|---|---|---|---|---|---|---|
| | | | Gold. | Silver. | Copper. | | Lead. | |
| | | | | | Metal | Ore. | | |
| | | | Troy Ounce | Troy Ounce | Long Tons | Long Tons. | Long Tons. | |
| Poropets | Hokkaidō | Oda Ryōji | 6,559.2 | 6,629.5 | 69.0 | — | — | 267 |
| Shiribeshi | ,, | Tokunaga Shigeyasu | 1,033.2 | 14,787.1 | — | — | — | 149 |
| Kosaka | Akita | Fujita & Co. | 10,490.8 | 1,110,707.2 | 7,086.2 | — | 372.2 | 7,642 |
| Taubaki | ,, | Takeda Kyōsaku | — | 1,244,572.8 | 273.9 | — | — | 1,365 |
| Ani | ,, | Furukawa Mining Co. | — | 44,948.3 | 1,284.6 | — | — | 3,560 |
| Osaruzawa | ,, | Mitsubishi & Co. | } 412.7 | 25,219.0 | 1,358.4 | — | — | 1,502 |
| Komaki | ,, | ,, | | | | | | 119 |
| Arakawa | ,, | ,, | — | — | 732.2 | — | — | 1,747 |
| Hisan-ichi | ,, | ,, | — | 34,508.0 | 689.7 | — | — | 753 |
| Furokura | ,, | Furukawa Mining Co. | — | — | 578.5 | — | — | 734 |
| Innai | ,, | ,, | 967.9 | 94,757.9 | 152.7 | — | — | 347 |
| Tokitō | ,, | Fujita & Co. | — | — | 279.0 | 4,078.3 | — | 375 |
| Hanaoka | ,, | Ishida Kumakichi | — | — | — | 4,203.2 | — | 90 |
| Daiji | ,, | Fujita & Co. | — | — | 74.5 | — | — | 117 |
| Matsuoka | ,, | ,, | 365.9 | 11,150.8 | — | — | — | 270 |
| Ōkuzu | ,, | Mitsubishi & Co. | 48.0 | 89.0 | — | 1,914.7 | — | 121 |
| Midzusawa | Iwate | Furukawa Mining Co. | — | — | 255.6 | — | — | 733 |
| Kamaishi | ,, | Tanaka Chōb | 2,013.4 | — | 47.5 | 3,288.1 | — | 4,555 |
| Washinosu | ,, | Tameda Buntarō | 1,346.2 | 83.6 | — | — | — | 253 |
| Ōarazawa | ,, | Saitō Tatsugorō | — | — | 73.8 | — | — | 78 |
| Unekura | ,, | Satō Jirō | — | — | 74.2 | — | — | 126 |
| Shishiori | Miyagi | Tokunaga Shigeyasu | 2,041.7 | 569.2 | — | — | — | 150 |
| Nagamatsu | Yamagata | Furukawa Mining Co. | — | 12,993.2 | 259.2 | — | — | 504 |
| Ōtori | ,, | ,, | — | 8,988.4 | 122.9 | — | — | 378 |
| Karatoya | ,, | Karatoya Mining Co. | — | — | 1.4 | 429.8 | — | 101 |
| Yoshino | ,, | Yokota Ichisaku and others | — | — | — | 143.2 | — | 65 |
| Kanō | Fukushima | Kanō Mining Co. | 781.1 | 91,624.7 | 974.0 | — | — | 2,181 |
| Handa | ,, | Godai Rinsaku | 656.9 | 21,249.4 | — | — | — | 112 |
| Yakuki | ,, | Yakuki Mine Co. | — | — | 113.5 | — | — | 109 |
| Sado | Niigata | Mitsubishi & Co. | 13,740.0 | 113,651.9 | 3.7 | — | — | 1,238 |
| Kusakura | ,, | Furukawa Mining Co. | — | — | 237.7 | — | — | 489 |
| Hirotani | ,, | ,, | — | — | 61.8 | — | — | 139 |
| Ashio | Tochigi | ,, | — | 75,082.4 | 6,972.4 | — | — | 7,274 |
| Kobyaku | ,, | Kobyaku Mining Co. | — | — | 154.0 | — | — | 150 |
| Hitachi | Ibaraki | Kuhara Fusanosuke | 1,558.4 | 30,615.5 | 1,871.5 | — | — | 1,013 |

| Mines. | Prefectures. | Concessionaires. | Output. | | | | | No. of Labourers. |
|---|---|---|---|---|---|---|---|---|
| | | | Gold. | Silver. | Copper. | | Lead. | |
| | | | | | Metal. | Ore. | | |
| | | | Troy Ounce. | Troy Ounce | Long Tons | Long Tons | Long Tons. | |
| Takara | Yamanashi | Mitsubishi & Co. | — | — | 109.7 | — | — | 95 |
| Kune | Shidzuoka | Furukawa Mining Co. | — | — | — | 43,018.2 | — | 438 |
| Ōmatsuyama | ,, | Kurotaki Chōjirō | 512.4 | 3,608.9 | — | — | — | 44 |
| Kamioka | Gifu | Mitsui Mining Co. | 246.4 | 169,529.8 | 38.9 | — | 2,129.8 | 2,251 |
| Hiragane | ,, | Yokoyama Takaoki | — | 38,996.3 | 509.7 | — | — | 824 |
| Takane | ,, | Asada Sayemon | — | 14,168.3 | 141.6 | — | — | 227 |
| Hatasa | ,, | Okunō Mining Co. | — | 25,327.9 | 44.7 | — | — | 182 |
| Ogoya | Ishikawa | Yokoyama Takatoshi | — | — | 685 4 | — | — | 1,143 |
| Yūsenji | ,, | Yoshinotani Coal Mine Co. | — | — | 610.5 | — | — | 880 |
| Kuratani | ,, | Kuratani Mine Co. | 2,415.7 | 38,535.1 | 2.5 | — | 184.0 | 352 |
| Kanahira | ,, | Murata Sukematsu | 1,066.4 | — | — | — | — | 424 |
| Ate | ,, | Moriyama Saichi | — | — | 60.4 | — | — | 160 |
| Togi | ,, | Kinoshita Ryō and others | 697.0 | 624.5 | — | — | — | 138 |
| Omodani | Fukui | Mitsubishi & Co. | 7.2 | 28,689.1 | 182.8 | — | — | 360 |
| Takamasa | Shiga | Osaka Mining Co. | — | 848.3 | 9.9 | — | — | 23 |
| Iimori | Wakayama | Nakae Tanezō | — | — | 75.3 | — | — | 70 |
| Kyōsei | Nara | Tanaka Ginnosuke | — | — | — | 4,875.6 | — | 120 |
| Ikuno | Hyōgo | Mitsubishi & Co. | 3,881.0 | 211,865.5 | 1,152.1 | 4,215.1 | — | 1,949 |
| Kanasaka | ,, | Hayashi Heizō and others | — | — | 37.9 | — | — | 79 |
| Karatani-Kawakami | ,, | Tsuchiya Minekichi | — | 3,072.0 | 27.9 | — | — | 78 |
| Tada | ,, | Hori Tōjūrō | — | 4,656.2 | 18.7 | — | 0.5 | — |
| Ōmori | Shimane | Fujita & Co. | 1,689.6 | 96,153.6 | 314.2 | — | 4.1 | 675 |
| Hōmanzan | ,, | Hori Tōjūrō | — | — | 270.9 | — | — | 491 |
| Sasagatani | ,, | ,, | — | 12,210.0 | 144 3 | — | — | 296 |
| Dōgamaru | ,, | ,, | — | 9,504 0 | 56.7 | — | — | 166 |
| Kuki | ,, | ,, | — | 20,291.6 | — | — | 102.5 | 105 |
| Wanibuchi | ,, | Wanibuchi Mining Co. | — | — | 11.1 | 1,254 2 | — | 111 |
| Yoshioka | Okayama | Mitsubishi & Co. | 138.8 | 60,590.4 | 778 5 | — | — | 1,273 |
| Obiye | ,, | Sakamoto & Co. | — | — | 736 4 | — | — | 813 |
| Mihara | ,, | Utsunomiya Mining Co. | — | — | — | 1,616.8 | — | 177 |
| Kokusei | ,, | Sudzuki Yekiji | — | — | 116.5 | 273 7 | — | 68 |
| Konjō | ,, | Sakata Mitsugi | — | 8,559.9 | 41.9 | — | — | 182 |
| Yamate | ,, | Nomura Chōbei | — | 2,380.5 | 31.1 | — | — | 66 |
| Hisaki | ,, | Kusakabe Toraji | — | — | — | 287 2 | — | 50 |
| Mochibe | Tokushima | Shima Tokuzō | — | — | — | 13,816 9 | — | 335 |
| Higashiyama | ,, | ,, | — | — | — | 2,963.5 | — | 2,687 |
| Besshi | Yehime | Sumitomo Kichizaemon | — | — | 5,173.3 | — | — | 3,477 |
| Chibara | ,, | Yabuuchi Senzō | — | — | 170.5 | — | — | 165 |
| Kanayama | ,, | Mitsubishi & Co. | — | — | — | 7,841 9 | — | 224 |
| Nishinokawa | ,, | Sumitomo Kichizaemon | — | — | 87.8 | — | — | 161 |
| Kuchō | ,, | Seike Kumeichirō | — | — | — | 1,988.2 | — | 195 |
| Hirabaye | ,, | Yamashita Kiichirō | — | — | — | 4,136.0 | — | 75 |
| Ōmine | ,, | Shiraishi Watarō | — | — | — | 1,956.0 | — | 123 |

| Mines. | Prefectures. | Concessionaires. | Output. Gold. | Output. Silver. | Output. Copper. Metal. | Output. Copper. Ore. | Output. Lead. | No. of Labourers. |
|---|---|---|---|---|---|---|---|---|
| | | | Troy Ounce. | Troy Ounce. | Long Tons. | Long Tons. | Long Tons. | |
| Kajitani | Yehime | Shiraishi Watarō | — | — | — | 2,097.1 | — | 73 |
| Takaura | ,, | Fujino Kamenosuke | — | — | — | 1,615.1 | — | 35 |
| Ōye | ,, | Yano Shōzaburō | — | — | — | 603.6 | — | 69 |
| Nagamine | ,, | Ueda Seiichi and others | — | — | — | 305.1 | — | 26 |
| Naganobori | Yamaguchi | Hori Tōjūrō | — | 6,693.1 | 115.2 | — | — | 176 |
| Yakuōji | ,, | Kawabe Kurosaburo | — | — | 53.2 | 871.1 | — | 191 |
| Ōta | ,, | Ikuta Kunizo and others | 5.3 | 2,389.4 | 64.1 | — | — | 133 |
| Kitsunedzuka | ,, | Kuwabara Masashi & others | — | — | 24.0 | — | — | 41 |
| Yano | Fukuoka | Yano Tomokichi | 781.9 | 557.0 | — | — | — | 218 |
| Taiōno | Ōita | Nangō Tokunosuke & others | 3,099.4 | 2,035.2 | — | — | — | 226 |
| Mizobe | ,, | Kojima Tetsutarō | 352.0 | 231.7 | — | — | — | 95 |
| Iwaya | Kumamoto | Noda Kichibei | — | — | 71.5 | — | — | 57 |
| Hibira | Miyazaki | Naito Seikyo | — | — | 870.3 | — | — | 1,021 |
| Makimine | ,, | Mitsubishi & Co. | — | — | 541.6 | — | — | 866 |
| Yamagano | Kagoshima | Shimadzu Tadashige | 12,167.5 | 26,735.3 | — | — | — | 2,219 |
| Ushio | ,, | Ushio Gold Mine Co. | 8,932.2 | 3,426.6 | — | — | — | 477 |
| Ōkuchi | ,, | Iwatsuki Naohiko and others | 4,766.8 | 2,115.2 | — | — | — | 424 |
| Serigano | ,, | Shimadzu Tadashige | 2,496.4 | 9,714.6 | — | — | — | 618 |
| Nitabira | ,, | Nagai Eikichi and others | 1,325.9 | 2,847.7 | — | — | — | 198 |
| Urushi | ,, | Kumimura Ryōsuke & others | 1,181.6 | 4,254.4 | — | — | — | 243 |
| Fuke | ,, | Asano Sōichirō | 884.8 | 701.3 | — | — | — | 87 |
| Bezaiten | ,, | Hitaka Shōkō and others | 179.3 | 24,271.6 | — | — | — | 98 |
| Ōtani | ,, | Satsunan Mining Co. | 663.5 | 363.0 | — | — | — | 212 |
| Kago | ,, | Horinouchi Shōnemon | 300.6 | 202.1 | — | — | — | 310 |
| Hashima | ,, | ,, | 145.7 | 693.1 | — | — | — | 17 |
| Kinkwaseki | Taiwan (Formosa) | Tanaka Chōbei | 33,353.3 | 25,558.0 | 319.0 | — | — | 904 |
| Botankō | ,, | Kimura Kintarō | 9,193.7 | 3,873.1 | — | — | — | 479 |
| Zuihō | ,, | Fujita & Co. | 8,961.9 | 3,984.4 | — | — | — | 550 |

## II. Mines of Antimony, Iron, Manganese, and Sulphur.

| Mines. | Prefectures. | Concessionaires. | Output. | | | | No. of Labourers. |
|---|---|---|---|---|---|---|---|
| | | | Antimony. | Iron. | Manganese ore. | Sulphur. | |
| | | | Long Tons. | Long Tons. | Long Tons. | Long Tons. | |
| Oshino | Hokkaidō | Oshino Kyō | — | — | 7,455.9 | 9,457 8 | 469 |
| Kobui | ,, | Senshō Mining Co. | — | — | — | 5,574.9 | 259 |
| Iwaonupuri | ,, | Mitsui Mining Co. | — | — | 1,455.5 | 3,002.0 | 286 |
| Kumadomari | ,, | Endō Kichihei | — | — | — | 2,006.9 | 147 |
| Shikabe | ,, | Oshima Mining Co. | — | — | — | 1,790 7 | 143 |
| Uguisuzawa | Iwate | Satō Seibei and others | — | — | — | 592.1 | 69 |
| Kamaishi | ,, | Tanaka Chōbei | — | 36,662.4 | — | — | 4,555 |
| Sennin | ,, | Sennin Iron Foundry Co. | — | 1.018.6(ore) 2,885.7 | — | — | 958 |
| Numajiri | Fukushima | Japan Sulphur Co. | — | — | — | 5,284.0 | 218 |
| Ichinokawa | Ehime | Ichinokawa Mining Co. | 158.3 | — | — | — | 259 |
| Kokonoeyama | Ōita | Hiromi Nisaburō | — | — | — | 1,328.1 | 56 |
| Kano | Yamaguchi | Sunohara Kumajirō & others | (ore) 259.2 | — | — | — | 65 |
| Iwōjima | Kagoshima | Hiromi Nisaburō | — | — | — | 607.5 | 76 |

## III. Coal Mines.

| Mines. | Prefectures. | Concessionnaires. | Output. Long Tons. | No. of Labourers. |
|---|---|---|---|---|
| Yūbari, 1st. | Hokkaidō | Hokkaidō Colliery Steamship Co. | 488,126.9 | 5,008 |
| Sorachi | ,, | ,, ,, | 247,379.5 | 1,957 |
| Shin-Yūbari | ,, | Ishikari Coal Co. and others | 165,390.8 | 1,583 |
| Horonai | ,, | Hokkaidō Colliery Steamship Co. | 187,269.6 | 1,238 |
| Yūbari, 2nd. | ,, | ,, ,, | 116,726.2 | 913 |
| Ikushumpets | ,, | ,, ,, | 76,847.4 | 718 |
| Pompets | ,, | Nippon Kōgyō Co. | 83,015.3 | 395 |
| Uchigō | Fukushima | Iwaki Coal Mine Co. | 198,936.3 | 1,408 |
| Onoda | ,, | ,, | 190,562.4 | 1,194 |
| Iriyama | ,, | Iriyama Coal Mining Co. | 194,742.5 | 1,402 |
| Yoshima | ,, | Yoshima Coal Mining Co. | 126,826.9 | 1,348 |
| Ōjō | ,, | Ōjō Coal Mining Co. | 68,694.2 | 441 |
| Sansei | ,, | Sansei Coal Mining Co | 69,698.1 | 548 |
| Ibaraki Saitan | Ibaraki | Ibaaaki Coal Mining Co. | 69,733.6 | 593 |
| Ibaraki Muentan | ,, | Ibaraki Anthracite Mining Co. | 59,042.2 | 622 |
| Ōmine | Yamaguchi | Navy Department | 96,885.7 | 974 |
| Okinoyama | ,, | Watanabe Yūsaku | 53,282.7 | 508 |
| Kata | ,, | Noda Kichibei and others | 58,826.8 | 149 |
| Ōtsuji, 4th. | Fukuoka | Kaijima Tasuke | 197,115.8 | 1,691 |
| Ōtsuji | ,, | ,, | 167,959.6 | 1,447 |
| Miyoshi | ,, | Miyoshi Tokumatsu | 120,653.1 | 731 |
| Iwasaki | ,, | Iwasaki Kumekichi | 85,417.7 | 486 |
| Nakatsuru | ,, | Itō Denyemon | 57,656.4 | 371 |
| Arata | ,, | ,, | 54,450.9 | 558 |
| Ōnoura | ,, | Kaijima Tasuke | 771,290.8 | 6,195 |
| Shinnyū | ,, | Mitsubishi & Co. | 426,621.0 | 4,945 |
| Meiji | ,, | Meiji Mining Co. | 419,793.9 | 3,186 |
| Shiogashira and Shakano-o | ,, | Furukawa Mining Co. | 373,198.0 | 2,705 |
| Mitsui-Hondō | ,, | Mitsui Mining Co. | 195,914.8 | 3,084 |
| Kaigun Gotoku | ,, | Nevy Department | 213,383.4 | 1,532 |
| Koyanose (508) | ,, | Yegi Iwakichi | 83,141.3 | 553 |
| Koyanose (101) | ,, | ,, | 46,730.8 | 180 |
| Namadzuda | ,, | Mitsubishi & Co. | 271,836.0 | 2,207 |
| Futase | ,, | Government Steel Works | 354,935.9 | 2,629 |
| Yoshio | ,, | Asō Takichi | 243,306.0 | 1,792 |
| Mitsui-Yamano | ,, | Mitsui Mining Co. | 177,693.8 | 2,320 |
| Tadakuma | ,, | Sumitomo Kichizayemon | 168,959.3 | 1,697 |
| Mameda | ,, | Asō Takichi | 150,178.0 | 1,076 |
| Aida | ,, | Nakano Tokujiro and others | 97,310.8 | 452 |
| Kamiyamada | ,, | Mitsubishi & Co. | 93,850.4 | 1,021 |

| Mines. | Prefectures. | Concessionaires. | Output. Long Tons. | No. of Labourers. |
|---|---|---|---|---|
| Muta | Fukuoka | Itō Denyemon | 91,832.8 | 758 |
| Shimoyamada | ,, | Furukawa Mining Co. | 105,335.9 | 1,103 |
| Hirayama | ,, | Tajima Shinobu | 32,720.7 | 537 |
| Honami | ,, | Ishida Osamu | 16,120.2 | 166 |
| Mitsui-Tagawa | ,, | Mitsui Mining Co. | 536,290.0 | 4,460 |
| Kanada | ,, | Mori Motoaki | 290,978.6 | 2,442 |
| Ōtō | ,, | Buzen Coal Mining Co. | 171,546.0 | 1,305 |
| Akaike | ,, | Meiji Mining Co. | 172,952.2 | 1,444 |
| Hōkoku | ,, | ,, | 127,083.8 | 1,454 |
| Hōjō | ,, | Mitsubishi & Co. | 96,648.4 | 1,188 |
| Miyazaki-Hōshū | ,, | Miyazaki Giichi | 106,002.3 | 929 |
| Mineji | ,, | Kashiwagi Kanpachirō | 66,569.3 | 1,450 |
| Honsoeda | ,, | Masuya Hikosuke | 60,447.8 | 353 |
| Miyao | ,, | Kurachi Jiichi | 66,788.8 | 362 |
| Soeda | ,, | Abe Yasujirō | 53,054.4 | 645 |
| Kigyo-Komatsu-Gotoji | ,, | Kurachi Shigehiko | 64,765.3 | 556 |
| Kaharu | ,, | Kuwahara Masashi | 47,257.3 | 669 |
| Tsubakuro | ,, | Kaijima Tasuke | 81,214.2 | 835 |
| Kaigun Shimbaru | ,, | Navy Department | 81,921.1 | 1,318 |
| Sasakuri | ,, | Yonezawa Tokichi | 60,593.2 | 354 |
| Ueki | ,, | Okada Sango | 53,389.9 | 334 |
| Miike | ,, | Mitsui Mining Co. | 1,513,388.6 | 9,976 |
| Yoshinotani | Saga | Yoshinotani Coal Mining Co. | 251,770.7 | 3,160 |
| Ōchi | ,, | Mitsubishi & Co. | 161,468.0 | 2,476 |
| Kishidake | ,, | Koga Seijiro and others | 83,017.3 | 1,188 |
| Akasakaguchi | ,, | Takatori Koreyoshi | 124,462.9 | 1,547 |
| Yunokibara | ,, | Kaijima Tasuke | 87,350.7 | 1,149 |
| Kishima, 2nd. | ,, | Tajima Shinobu | 61,926.9 | 1,171 |
| Kishima | ,, | Hieda Ichirōji and others | 71,243.3 | 1,892 |
| Takashima | Nagasaki | Mitsubishi & Co. | 184,816.9 | 2,693 |
| Matsushima | ,, | Koga Shun-ichi | 78,753.7 | 1,326 |
| Matsura | ,, | Matsura Coal Mining Co. | 80,719.2 | 486 |

## IV. Oil Fields.

| Oil Fields. | Prefectures. | Concessionaires. | Output* Barrels (42 gallons) | No. of Labourers. |
|---|---|---|---|---|
| Koguchi | Niigata. | Hōden Oil Co. | 247,151.6 | 143 |
| Niitsu | ,, | Nippon Oil Co. | 170,230.7 | 254 |
| Kanatsu | ,, | Hōden Oil Co. | 129,325.0 | 77 |
| Kanatsu | ,, | Nakano Kanichi & Others | 86,018.2 | 95 |
| Asahi | ,, | Uchida Sansei | 54,340.0 | 10 |
| Asahi (19) | ,, | Chūō Oil Co. | 41,001.1 | 81 |
| Kumazawa | ,, | Hōden Oil Co. | 31,421.6 | 82 |
| Asahi (349) | ,, | Chūō Oil Co. | 21,349.0 | 86 |
| Koguchi | ,, | Fuji Oil Co. | 19,629.5 | 13 |
| Asahi the fifth | ,, | Nakano Chutaro | 17,008.0 | 43 |
| Higashiyama | ,, | Hōden Oil Co. | 234,477.3 | 1,522 |
| Urase | ,, | Nippon Oil Co. | 49,886.4 | 54 |
| Nagamine | ,, | ,, | 331,920.5 | 706 |
| Nagamine | ,, | Hōden Oil Co. | 163,690.9 | 140 |
| Kamada | ,, | ,, | 47,129.5 | 55 |
| Maki | ,, | Nippon Oil Co. | 31,812.5 | 239 |
| Maki | ,, | Hōden Oil Co. | 31,343.2 | 160 |

* The output is calculated as crude oil.

phur.

| Value in Pounds. |
|---|
| 1,042.4 |
| 1,051.4 |
| 2,508.0 |
| 2,377.6 |
| 3,861.8 |
| 3,115.9 |
| 2,139.9 |
| 1,253.2 |
| 4,481.2 |
| 14,042.1 |
| 15,990.9 |
| 8,274.0 |
| 9,852.9 |
| 14,433.3 |
| 21,816.6 |
| 29,369.1 |
| 30,158.4 |
| 34,000.4 |
| 41,245.2 |
| 44,079.8 |
| 30,206.1 |
| 24,208.2 |
| 25,113.7 |
| 33,593.1 |
| 29,497.8 |
| 28,865.0 |
| 33,515.6 |
| 43,091.8 |
| 48,285.8 |
| 61,830.8 |
| 65,116.8 |
| 60,306.7 |
| 62,974.1 |
| 81,728. |
| 79,269. |

| phur. | Graphite. | | Coal. | | Petroleum. | | Others. | | Total Value in Pounds. |
|---|---|---|---|---|---|---|---|---|---|
| Value in Pounds. | Weight in long tons. | Value in Pounds. | Weight in long tons | Value in Pounds. | Volume U. S. Barrels. | Value in Pounds. | Weight in long tons. | Value in Pounds. | |
| 1,042.4 | — | — | 204,864 | 49,065.1 | 3,499 | 2,444.6 | — | — | 154,689.5 |
| 1,051.4 | — | — | 558,288 | 114,838.8 | 5,489 | 3,835.2 | — | — | 251,596.8 |
| 2,508.0 | — | — | 537,011 | 111,998.5 | 9,267 | 6,276.8 | — | — | 296,680.0 |
| 2,377.6 | — | — | 491,835 | 103,649.0 | 12,628 | 8,030.5 | — | — | 339,135.6 |
| 3,861.8 | — | — | 669,806 | 146,797.5 | 21,500 | 15,022.7 | — | — | 397,432.8 |
| 3,115.9 | — | — | 845,057 | 161,395.3 | 28,199 | 19,703.5 | — | — | 518,846.0 |
| 2,139.9 | — | — | 865,201 | 212,270.5 | 30,651 | 21,417.2 | — | — | 672,509.8 |
| 1,253.2 | — | — | 911,720 | 225,233.3 | 20,138 | 14,070.5 | — | — | 711,241.0 |
| 4,481.2 | — | — | 915,676 | 265,982.2 | 23,311 | 17,642.5 | — | 12,550.7 | 733,326.5 |
| 14,042.1 | — | — | 987,818 | 236,385.1 | 24,613 | 10,666.8 | — | 10,597.3 | 647,863.6 |
| 15,990.9 | — | — | 1,123,330 | 242,170.3 | 7,063 | 10,796.4 | — | 7,307.2 | 669,652.7 |
| 8,274.0 | — | — | 1,274,775 | 266,238.5 | 8,324 | 9,849.6 | — | 7,172.7 | 689,819.0 |
| 9,852.9 | — | — | 1,354,190 | 280,360.3 | 15,326 | 13,691.1 | — | 11,515.4 | 739,943.0 |
| 14,433.3 | — | — | 1,720,909 | 307,701.0 | 10,034 | 12,629.8 | — | 16,027.6 | 819,993.1 |
| 21,816.6 | — | — | 1,893,970 | 409,060.2 | 45,006 | 13,860.2 | — | 17,928.6 | 1,190,585.8 |
| 29,369.1 | — | — | 2,353,849 | 541,723.4 | 63,490 | 25,097.7 | — | 15,035.8 | 1,346,495.5 |
| 30,158.4 | — | — | 2,589,997 | 623,366.2 | 61,817 | 22,147.8 | — | 15,151.0 | 1,553,309.7 |
| 34,000.4 | 241 | 915.5 | 3,129,581 | 657,399.7 | 63,618 | 20,702.9 | — | 1,452.2 | 1,575,904.5 |
| 41,245.2 | 59 | 318.6 | 3,129,409 | 606,870.5 | 82,333 | 22,530.2 | — | 35.3 | 1,567,851.7 |
| 44,079.8 | 27 | 241.6 | 3,271,244 | 625,744.8 | 106,983 | 20,649.3 | — | 1,155.8 | 1,604,974.2 |
| 30,206.1 | 1,066 | 2,515.7 | 4,214,253 | 1,020,511.1 | 172,711 | 26,163.5 | — | 1,701.5 | 2,124,435.4 |
| 24,208.2 | 428 | 781.0 | 4,718,914 | 1,275,787.5 | 169,873 | 38,227.8 | — | 1,701.5 | 2,574,327.1 |
| 25,113.7 | 210 | 2,594.8 | 4,946,568 | 1,187,423.3 | 236,819 | 35,160.7 | — | 2,004.8 | 2,425,844.6 |
| 33,593.1 | 382 | 6,168.9 | 5,131,628 | 1,909,692.1 | 262,751 | 34,821.9 | — | 596.5 | 3,223,879.2 |
| 29,497.8 | 339 | 6,238.6 | 6,640,468 | 2,709,954.7 | 319,015 | 34,896.2 | — | 314.6 | 4,165,230.9 |
| 28,865.0 | 52 | 969.6 | 6,653,476 | 2,306,362.5 | 539,098 | 104,369.4 | — | 1,737.9 | 4,505,481.4 |
| 33,515.6 | 92 | 2,385.5 | 7,362,891 | 2,474,326.5 | 871,740 | 194,201.3 | — | 2,139.2 | 5,053,924.5 |
| 43,091.8 | 86 | 1,743.3 | 8,879,511 | 3,084,254.6 | 1,117,995 | 227,882.1 | — | 1,274.5 | 5,990,027.2 |
| 48,285.8 | 95 | 1,984.2 | 9,656,295 | 3,255,718.7 | 997,543 | 207,784.0 | — | 475.8 | 5,987,649.8 |
| 61,830.8 | 111 | 2,199.4 | 10,021,893 | 2,925,307.2 | 1,210,340 | 281,936.2 | — | 316.6 | 6,132,127.2 |
| 65,116.8 | 212 | 3,708.8 | 10,619,026 | 2,947,678.7 | 1,220,744 | 278,060.6 | — | 271.8 | 6,249,036.2 |
| 60,306.7 | 201 | 3,651.8 | 11,467,845 | 4,050,127.9 | 1,352,574 | 296,948.1 | — | 371.5 | 8,504,621.9 |
| 62,974.1 | 138 | 2,444.9 | 12,892,721 | 6,348,445.7 | 1,571,367 | 317,901.1 | — | 867.8 | 11,599,555.0 |
| 81,728.4 | 101 | 1,046.9 | 13,736,182 | 6,041,584.6 | 1,727,298 | 527,749.6 | — | 1,861.2 | 12,141,716.6 |
| 79,269.1 | 147 | 1,726.3 | 14,761,476 | 6,416,698.4 | 1,872,592 | 658,598.4 | — | 7,885.0 | 11,638,667.2 |

# TABLE III.

## Annual Exports of the Mineral Products.

| Year. | Copper. | | Antimony. | | Manganese Ore. | | Sulphur. | | Coal. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Weight long tons | Value in pounds. | Weight long tons | Value in pounds | Weight long tons | Value in pounds. | Weight long tons | Value in pounds. | Weight long tons | Value in pounds. |
| 1868 | 64.7 | 2,822.7 | — | — | — | — | 116.1 | 647.9 | 16,529 | 8,428.0 |
| 1869 | 356.5 | 12,068.0 | — | — | — | — | 117.5 | 447.4 | 33,217 | 18,258.1 |
| 1870 | 732.2 | 20,819.4 | — | — | — | — | 115.2 | 546.1 | 56,008 | 29,834.4 |
| 1871 | 3,213.7 | 77,759.4 | — | — | — | — | 323.7 | 1,671.1 | 63,795 | 32,498.1 |
| 1872 | 4,800.0 | 131,244.8 | — | — | — | — | 498.6 | 1,448.7 | 58,272 | 33,591.6 |
| 1873 | 1,978.5 | 61,469.7 | — | — | — | — | 657.2 | 1,991.6 | 145,366 | 62,809.0 |
| 1874 | 2,917.0 | 55,038.9 | — | — | — | — | 1,277.7 | 3,555.5 | 117,600 | 55,534.1 |
| 1875 | 1,226.8 | 44,293.8 | — | — | — | — | 899.6 | 2,431.7 | 202,233 | 101,058.9 |
| 1876 | 820.3 | 29,141.8 | — | — | — | — | 1,365.8 | 4,128.2 | 164,255 | 77,624.2 |
| 1877 | 1,890.4 | 62,148.6 | — | — | — | — | 517.8 | 1,718.6 | 161,348 | 73,547.5 |
| 1878 | 2,773.1 | 85,215.7 | — | — | — | — | 1,296.8 | 3,553.1 | 204,251 | 88,351.7 |
| 1879 | 2,772.3 | 83,702.6 | — | — | — | — | 1,483.9 | 3,742.0 | 195,802 | 77,717.2 |
| 1880 | 1,545.9 | 47,423.6 | — | — | — | — | 1,600.4 | 3,731.9 | 286,252 | 108,614.1 |
| 1881 | 1,925.9 | 60,589.9 | 1,249 | 10,648.6 | — | — | 3,751.9 | 6,698.2 | 294,803 | 110,443.8 |
| 1882 | 2,733.7 | 84,867.1 | 1,119 | 10,111.2 | — | — | 1,141.9 | 3,122.5 | 324,671 | 117,734.3 |
| 1883 | 2,352.2 | 73,584.2 | 1,809 | 14,024.5 | — | — | 5,531.7 | 11,976.5 | 389,541 | 135,793.6 |
| 1884 | 5,185.3 | 141,346.6 | 973 | 7,384.7 | — | — | 3,265.1 | 6,664.5 | 519,295 | 180,993.2 |
| 1885 | 8,097.0 | 185,905.8 | 2,241 | 18,329.0 | — | — | 7,363.6 | 13,793.2 | 581,689 | 197,596.6 |
| 1886 | 9,662.7 | 220,346.5 | 1,947 | 15,431.9 | — | — | 5,358.3 | 7,676.3 | 669,043 | 220,894.9 |
| 1887 | 8,563.7 | 206,887.9 | 2,024 | 16,387.8 | — | — | 8,638.7 | 13,602.3 | 704,935 | 233,780.5 |
| 1888 | 9,536.3 | 353,660.9 | 1,291 | 15,332.0 | — | — | 6,749.2 | 12,090.3 | 975,289 | 318,603.7 |
| 1889 | 10,004.2 | 290,140.9 | 1,476 | 23,883.4 | — | — | 19,799.4 | 31,332.2 | 1,053,821 | 434,663.9 |
| 1890 | 19,180.8 | 537,762.1 | 1,675 | 34,996.2 | 600 | 756.6 | 18,361.7 | 26,328.4 | 1,214,572 | 479,608.9 |
| 1891 | 17,152.9 | 490,949.8 | 1,814 | 23,249.9 | 1,964 | 1,869.5 | 18,702.3 | 28,483.2 | 1,239,821 | 474,973.4 |
| 1892 | 17,826.4 | 490,218.3 | 1,209 | 16,330.9 | 8,232 | 9,584.1 | 12,902.7 | 28,096.3 | 1,299,352 | 457,198.3 |
| 1893 | 15,171.3 | 460,087.8 | 1,293 | 18,385.4 | 18,359 | 21,288.4 | 10,251.8 | 23,883.2 | 1,595,413 | 481,791.2 |
| 1894 | 15,080.1 | 492,959.7 | 1,584 | 25,426.1 | 17,324 | 19,881.0 | 12,455.2 | 24,454.2 | 1,701,130 | 657,846.1 |
| 1895 | 14,353.9 | 518,884.4 | 1,425 | 28,993.5 | 16,205 | 19,659.9 | 15,620.7 | 29,613.6 | 1,844,815 | 760,478.8 |
| 1896 | 14,355.8 | 551,231.9 | 612 | 8,380.6 | 20,616 | 27,443.4 | 12,113.2 | 30,858.8 | 2,194,412 | 887,925.6 |
| 1897 | 13,911.1 | 587,925.3 | 1,549 | 26,758.4 | 14,496 | 20,531.8 | 9,050.4 | 32,134.1 | 2,103,012 | 1,154,580.1 |
| 1898 | 16,422.7 | 738,955.6 | 1,317 | 21,659.8 | 9,825 | 15,633.3 | 12,430.8 | 47,701.4 | 2,186,790 | 1,516,879.9 |
| 1899 | 21,169.3 | 1,152,301.7 | 1,029 | 20,651.6 | 9,244 | 15,268.8 | 16,424.5 | 57,486.8 | 2,487,614 | 1,516,486.7 |
| 1900 | 20,424.2 | 1,292,241.7 | 371 | 10,770.8 | 12,696 | 22,439.7 | 17,558.7 | 69,828.4 | 3,349,548 | 2,003,212.0 |
| 1901 | 21,914.2 | 1,409,201.6 | 274 | 7,849.1 | 8,809 | 18,717.7 | 17,649.0 | 66,187.9 | 2,922,215 | 1,754,227.3 |
| 1902 | 20,764.2 | 1,056,262.8 | 1,141 | 27,161.2 | 2,650 | 5,253.9 | 20,941.8 | 75,908.3 | 2,938,741 | 1,727,041.8 |
| 1903 | 27,686.2 | 1,525,692.9 | 1,762 | 38,862.8 | 3,289 | 7,789.2 | 25,131.2 | 94,722.5 | 3,433,459 | 1,926,050.5 |
| 1904 | 21,333.5 | 1,342,276.1 | 1,261 | 26,892.3 | 3,412 | 8,844.8 | 25,182.0 | 95,030.9 | 2,878,503 | 1,482,809.2 |
| 1905 | 20,268.5 | 1,618,598.2 | 704 | 20,148.6 | 491 | 1,058.4 | 28,937.7 | 97,192.1 | 2,507,527 | 1,426,786.7 |
| 1906 | 33,695.8 | 2,531,133.4 | 299 | 20,536.4 | 8,343 | 13,806.3 | 37,004.3 | 120,191.1 | 2,402,354 | 1,628,007.2 |
| 1907 | 31,777.1 | 2,947,764.6 | 150 | 9,075.2 | 4,992 | 12,107.2 | 30,897.5 | 109,138.9 | 2,922,490 | 1,905,288.6 |
| 1908 | 35,866.0 | 2,157,764.8 | 205 | 5,996.9 | 4,313 | 11,609.1 | 30,055.5 | 103,749.6 | 2,863,116 | 1,823,398.0 |

| Year. | Copper. | |
|---|---|---|
| | Weight in long tons | Value in pounds |
| 1868 | 149.6 | 4,311 9 |
| 1869 | 5.3 | 255 8 |
| 1870 | — | 650 5 |
| 1871 | 2.3 | 97.4 |
| 1872 | 7.8 | 290.8 |
| 1873 | 39.5 | 1,539.7 |
| 1874 | 10.9 | 648.1 |
| 1875 | 18.9 | 1,102.5 |
| 1876 | 47.1 | 2,756.2 |
| 1877 | 32.5 | 1,430.3 |
| 1878 | 97.6 | 3,853 8 |
| 1879 | 17.4 | 654.2 |
| 1880 | 47.9 | 1,874.7 |
| 1881 | 37.7 | 1,426.4 |
| 1882 | 67.7 | 2,549.5 |
| 1883 | 57.1 | 3,526.7 |
| 1884 | 38.2 | 1,932.7 |
| 1885 | 59.0 | 3,334.6 |
| 1886 | 46.8 | 3,362.3 |
| 1887 | 39.3 | 1,828.7 |
| 1888 | 9.7 | 1,878.2 |
| 1889 | 15.2 | 2,660.7 |
| 1890 | 18.8 | 3,813.8 |
| 1891 | 77.6 | 6,259.8 |
| 1892 | 34.6 | 3,097.7 |
| 1893 | 3.4 | 2,048.9 |
| 1894 | 23.3 | 3,324.0 |
| 1895 | 68.7 | 14,259.1 |
| 1896 | 202.0 | 12,798.8 |
| 1897 | 180.2 | 12,486.4 |
| 1898 | 275.9 | 19,208.8 |
| 1899 | 238.9 | 20,819.7 |
| 1900 | 447.2 | 38,741.2 |
| 1901 | 576.0 | 49,442.8 |
| 1902 | 535.8 | 40,653.1 |
| 1903 | 742 9 | 49,051.6 |
| 1904 | 745.3 | 55,444.2 |
| 1905 | 3,990.1 | 267,205.8 |
| 1906 | 1,221.1 | 110,076.3 |
| 1907 | 876.1 | 94,429.8 |
| 1908 | 1,012.7 | 85,290 9 |

## TABLE V.

### Annual Consumption of Coal.*

| Year. | For Steamships. long tons. | For Locomotives. long tons. | For Factories. long tons. | For Salt Works. long tons. | Total Quantity. long tons. |
|---|---|---|---|---|---|
| 1886 | 233,668 | 18,038 | 144,429 | 449,146 | 845,281 |
| 1887 | 255,201 | 19,478 | 161,412 | 389,173 | 825,264 |
| 1888 | 383,318 | 26,525 | 281,828 | 378,177 | 1,069,848 |
| 1889 | 387,206 | 43,381 | 362,086 | 353,632 | 1,146,305 |
| 1890 | 453,916 | 67,820 | 417,900 | 469,734 | 1,409,370 |
| 1891 | 437,453 | 97,155 | 504,770 | 448,213 | 1,487,591 |
| 1892 | 425,288 | 126,414 | 712,100 | 432,903 | 1,696,705 |
| 1893 | 431,622 | 124,232 | 718,314 | 451,080 | 1,725,248 |
| 1894 | 511,863 | 164,123 | 1,076,703 | 520,366 | 2,278,055 |
| 1895 | 729,938 | 217,991 | 1,171,210 | 509,861 | 2,629,000 |
| 1896 | 677,056 | 254,197 | 1,530,331 | 538,658 | 3,000,242 |
| 1897 | 873,111 | 831,107 | 1,805,482 | 489,282 | 3,998,982 |
| 1898 | 773,420 | 381,809 | 2,490,938 | 648,255 | 4,294,422 |
| 1899 | 1,216,882 | 488,735 | 2,556,788 | 659,551 | 4,921,956 |
| 1900 | 1,431,136 | 495,594 | 2,593,323 | 624,284 | 5,144,337 |
| 1901 | 1,366,760 | 613,654 | 3,758,240 | 793,522 | 6,532,176 |
| 1902 | 1,511,872 | 683,776 | 3,423,734 | 777,478 | 6,396,860 |
| 1903 | 1,718,875 | 721,291 | 3,620,859 | 810,240 | 6,871,265 |
| 1904 | 2,195,586 | 747,677 | 3,651,184 | 712,728 | 7,307,175 |
| 1905 | 1,967,912 | 829,304 | 3,721,243 | 491,579 | 7,010,038 |
| 1906 | 1,778,438 | 1,026,625 | 3,718,999 | 650,292 | 7,174,354 |
| 1907 | 2,298,982 | 1,028,634 | 4,356,005 | 762,895 | 8,446,516 |
| 1908 | 2,279,732 | 1,228,952 | 4,252,061 | 810,160 | 8,570,906 |

* Besides the figures indicated below coals may be consumed for other purposes of which statistics are not available.

## TABLE VI.

### Concessions, Number and Area.

| Year. | Number. | Area in acres. |
|---|---|---|
| 1889 | 3,801 | 45,039.31 |
| 1890 | 6,014 | 84,985.98 |
| 1891 | 7,469 | 100,975.41 |
| 1892 | 7,927 | 122,142.61 |
| 1893 | 9,213 | 824,186.34 |
| 1894 | 9,820 | 1,105,278.61 |
| 1895 | 8,248 | 953,711.70 |
| 1896 | 8,293 | 1,078,139.02 |
| 1897 | 9,390 | 1,611,622.01 |
| 1898 | 9,390 | 1,765,953.30 |
| 1899 | 9,469 | 1,856,057.46 |
| 1900 | 10,790 | 2,280,048.06 |
| 1901 | 12,766 | 2,776,787.82 |
| 1902 | 12,607 | 2,684,339.60 |
| 1903 | 11,990 | 2,565,630.95 |
| 1904 | 11,031 | 2,382,299.88 |
| 1905 | 8,586 | 1,495,612.46 |
| 1906 | 8,964 | 1,669,250.97 |
| 1907 | 10,828 | 2,302,177.24 |
| 1908 | 11,099 | 2,362,777.94 |

## TABLE VII.

### Number of Persons Employed and Deaths from Accidents.

| Year. | Number of Persons employed. | Number of Deaths from Accidents. | | |
|---|---|---|---|---|
| | | Coal mines. | Other mines. | Total. |
| 1897 | 160,539 | 13 | 2 | 15 |
| 1898 | 132,731 | 15 | 4 | 19 |
| 1899 | 119,667 | 270 | 404 | 674 |
| 1900 | 131,011 | 43 | 128 | 171 |
| 1901 | 145,755 | 180 | 39 | 219 |
| 1902 | 146,939 | 135 | 193 | 328 |
| 1903 | 157,129 | 215 | 94 | 309 |
| 1904 | 164,858 | 189 | 78 | 267 |
| 1905 | 154,975 | 256 | 74 | 330 |
| 1906 | 187,922 | 560 | 203 | 763 |
| 1907 | 214,435 | 468 | 113 | 581 |
| 1908 | 205,144 | 236 | 78 | 314 |

# TABLE VIII.

## Daily Wages.

### Metal Mines.

| Year. | 1906. | | | 1907. | | | 1908. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Men | Women | Boys. | Men. | Women. | Boys. | Men. | Women. | Boys. |
| | Penny | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. |
| Miners | 13.1 | 6.1 | — | 16.3 | 7.0 | 4.1 | 17.4 | — | — |
| Timbermen | 12.7 | — | — | 15.8 | — | 3.0 | 17.6 | — | — |
| Miners' helpers | 7.1 | 5.2 | 4.0 | 11.3 | 6.1 | 4.6 | 10.9 | 6.5 | 4.6 |
| Dressing hands | 7.9 | 4.2 | 2.6 | 10.1 | 5.4 | 3.2 | 9.5 | 5.6 | 3.7 |
| Smelters | 9.9 | 4.5 | 3.3 | 11.7 | 5.4 | 4.9 | 12.9 | 5.4 | 3.7 |
| Porters | 9.9 | 5.3 | 4.8 | 14.4 | 6.5 | 5.1 | 14.0 | 10.6 | 5.1 |
| Engine drivers, blacksmiths, carpenter, and mechanics | 11.6 | 4.0 | 2.8 | 12.6 | 5.0 | 3.7 | 13.0 | — | 5.3 |
| Others | 8.5 | 4.4 | 3.0 | 10.9 | 5.0 | 3.7 | 11.3 | 5.2 | 4.4 |

### Coal Mines.

| Year. | 1906. | | | 1907. | | | 1908. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Men. | Women. | Boys. | Men. | Women. | Boys. | Men. | Women. | Boys |
| | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. |
| Miners | 17.4 | 10.5 | 6.5 | 21.2 | 11.7 | 8.8 | 23.7 | 16.8 | 8.8 |
| Timbermen | 15.9 | 11.3 | 5.0 | 20.0 | 13.4 | 6.1 | 20.5 | 14.1 | 7.6 |
| Miners' helpers | 11.7 | 10.9 | 6.0 | 11.5 | 9.8 | 7.1 | 22.2 | 11.5 | 4.3 |
| Dressing hands | 9.0 | 6.5 | 4.0 | 9.0 | 5.6 | 4.0 | 10.0 | 6.1 | 4.1 |
| Porters | 11.9 | 7.3 | 5.0 | 14.1 | 9.0 | 4.6 | 15.4 | 9.3 | 5.6 |
| Engine drivers, blacksmiths, carpenters and mechanics | 13.1 | 5.0 | 5.2 | 12.7 | 10.0 | 5.4 | 14.1 | 7.1 | 5.4 |
| Others | 10.1 | 6.7 | 4.7 | 10.7 | 6.3 | 5.1 | 10.5 | 6.6 | 5.1 |

### Oil Fields.

| Year. | 1906. | | | 1907. | | | 1908. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Men | Women. | Boys and Girls. | Men. | Women | Boys and Girls. | Men. | Women. | Boys and Girls. |
| | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. | Penny. |
| Drillers | 8.5 | — | — | 9.3 | — | — | 9.8 | — | — |
| Blacksmiths | 9.5 | — | — | 10.8 | — | — | 10.8 | — | 4.4 |
| Carpenters | 9.5 | — | — | 10.5 | — | — | 11.0 | — | — |
| Refiners | 7.5 | 4.3 | — | 9.0 | — | — | 9.8 | 5.0 | — |
| Others | 7.8 | 4.4 | — | 7.8 | 5.1 | — | 8.5 | 5.4 | — |

## TABLE IX.

### Number of Horse Power Used.

| | Year. | 1906. | | 1907. | | 1908. | |
|---|---|---|---|---|---|---|---|
| | | Number | H.P. | Number | H.P. | Number | H.P. |
| Metal mines | Boilers | 163 | 9.543 | 184 | 10,735 | 188 | 14,543 |
| | Engines | 149 | 7,507 | 151 | 8,274 | 150 | 11,352 |
| | Electric motors | 279 | 10,720 | 415 | 13,767 | 562 | 19,842 |
| | Oil and gas engines | 28 | 1,679 | 20 | 197 | 28 | 390 |
| | Water wheels | 144 | 11,044 | 175 | 16,141 | 190 | 23,110 |
| Non-metal mines | Boilers | 1,110 | 64,597 | 1,229 | 96,505 | 1,364 | 100,779 |
| | Engines | 1,573 | 64,389 | 2,102 | 76,732 | 2,351 | 93,529 |
| | Electric motors | 140 | 4,185 | 173 | 7,729 | 299 | 10,461 |
| | Oil and gas engines | 62 | 398 | 107 | 878 | 152 | 1,196 |
| | Water wheels | 0 | 0 | 2 | 224 | 2 | 275 |

## TABLE X.

### Transportation in Mines.

| | Year. | 1906. | | | 1907. | | | 1808. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. of mines. | Length. | | No. of mines. | Length | | No. of mines. | Length. | |
| | | | mile | chain | | mile | chain | | mile | chain |
| Railways | In metal mines | 72 | 491 | 72 | 93 | 578 | 22 | 109 | 621 | 38 |
| | In coal mines | 56 | 582 | 9 | 67 | 780 | 45 | 74 | 877 | 14 |
| | In non-metal mines except coal mines | 6 | 12 | 48 | 8 | 14 | 8 | 25 | 14 | 51 |
| Wire rope tramways | In metal mines | 24 | 64 | 27 | 26 | 78 | 20 | 27 | 83 | 74 |
| | In coal mines | 5 | 7 | 40 | 2 | 1 | 70 | 2 | 2 | 12 |
| | In non-metal mines except coal mines | 1 | 15 | 39 | 3 | 17 | 00 | 3 | 10 | 43 |
| Oil pipe-lines | In oil fields | 21 | 151 | 55 | 16 | 147 | 10 | — | 197 | 35 |

# CHAPTER II.

## Mineral Resources.

### GOLD.

History and Development:—Many localities where placer gold could be found were known from early times, but the majority of the mountain gold mines which are in working order now were first exploited during the 17th Century. Recently, since 1890, ten principal mines have been discovered; among them the three famous mines of Formosa and the largest deposits of Hasami are included. From the year 1875, the first definite recorded in Japan, the production of gold has procceded gradually until the year 1899. In that year the production rapidly increased owing to the discoveries of the placer gold of Yesashi in Hokkaidō together with the output from Formosa. During the five years after, 1899—1903, the placer gold in Japan was the most prosperous especially in the year 1901 when it reached the maximum development of nearly 45% of the total production of gold. Since 1903 the production was not so significant as before, due principally to the sudden decline of the placer working, though there was always a certain steady increase of the mountain gold. According to the latest statistics the production of the placer mines became only 4.8% of the total output of gold.

The relation between the mountain gold and placer gold for every year since 1896 was as follows:—

| Year. | Mountain gold (in Troy Ounces) | Placer gold (in Troy Ounces.) | Percentage of placer gold for the total production of gold |
|---|---|---|---|
| 1896 | 26,609 | 6,706 | 20.1 |
| 1897 | 26,176 | 7,417 | 22 0 |
| 1898 | 31,872 | 7,498 | 19.0 |
| 1899 | 36,491 | 22,120 | 37.7 |

| | | | |
|---|---|---|---|
| 1900 | 45,513 | 35,024 | 43.5 |
| 1901 | 62,748 | 50,909 | 44.8 |
| 1902 | 97,801 | 46,087 | 32.0 |
| 1903 | 115,319 | 24,203 | 17.3 |
| 1904 | 121,181 | 11,537 | 8.7 |
| 1905 | 39,168 | 7,449 | 5.1 |
| 1906 | 132,981 | 4,660 | 3.4 |
| 1907 | 124,742 | 4,756 | 2.7 |
| 1908 | 145,724 | 7,381 | 4.8 |

The output in 1908 amounted to 153,105 troy ounces valued at £633,780 a little inferior to that of petroleum and it occupies the fourth rank among the mineral products in Japan.

The outputs of the principal mines during 1907—1908 were as follows :—

| Mines. | Provinces. | 1908. (in Troy Ounces.) | 1907. (in Troy Ounces.) |
|---|---|---|---|
| Kinkwaseki | Formosa | 33,353 | 14,555 |
| Sado | Sado | 13,740 | 13,184 |
| Yamagano | Satsuma | 12,167 | 8,575 |
| Kosaka | Rikuchū | 10,490 | 9,775 |
| Botankō | Formosa | 9,194 | 13,300 |
| Zuihō | ,, | 8 962 | 10,636 |
| Ushio | Satsuma | 8,932 | 10,044 |
| Propets | Hokkaidō | 6,559 | 392 |
| Ōkuchi | Satuma | 4,767 | 5,962 |
| Ikuno | Tajima | 3,881 | 2,807 |
| Taion | Bungo | 3,099 | 2,634 |
| Serigano | Satsuma | 2,496 | 3,456 |
| Kuratani | Kaga | 2,416 | 2,380 |
| Shishiori | Rikuzen | 2,042 | 1,847 |
| Ōmori | Iwami | 1,690 | 1,334 |
| Washinosu | Rikuchū | 1,346 | 1,481 |
| Hitachi | Hitachi | 1,558 | 16 |
| Uruchi | Satsuma | 1,182 | 1,459 |
| Shiribeshi | Hokkaidō | 1,033 | — |
| Innai | Ugo | 968 | 1,600 |
| Fuke | Satsuma | 885 | 1,071 |
| Kanahira | Kaga | 1,066 | 614 |

About ten years ago, the prevailing method for the extraction of gold from the ore was only the process of amalgamation. In the year 1900, however, the process of cyaniding was first practiced at Hasami and in the next year at Ushio. Soon after it had made very decided progress and at present there are few mines which do not adopt this treatment. The slime process are practiced in a few mines. The smelting of cupriferous gold ores is gradually increasing the output of gold.

Kind of Ores :—Gold occurs chiefly in its native state, frequently mixed with pyrites, chalcopyrite, arsenopyrites, pyrrhotite, stibnite, etc. In rare cases it occurs as tellurides. The principal constituent of the gangue is quartz often with calcite or baryte. In many cases the ore is of a free-milling character but sometimes cleyey or refractory. Few gold ores are absolutely free from silver, and vice versa, so that there is a transition between argentiferous gold ore and auriferous silver ore.

Deposits and Geology :—The mode of occurrence of the gold ores in Japan is as follows :—

1. Fissure-filling or veins.
2. Impregnations.
3. Metasomatic deposits.
4. Contact-metamorphic deposits.
5. Mechanical detrital deposits.

(1.) Veins :—Most of the gold in Japan is obtained from this class. There are two prominently types viz. : (a) Quartz veins in the Pre-Tertiary rocks and (b) Quartz veins in the Tertiary rocks. In the former type the ore contains usually a less amount of metallic sulphides than from the veins in the Tertiary. Most of the mines are unprofitable owing to the smallness and the discontinuous character of the veins, though numerous and to the fact that they are of a low-grade ores. They are common in the sedimentary rocks of the Archaean, Paleozoic and Mesozoic ages, but they are especially abundant in the Paleozoic, forming lenticular and bedded veins. In the latter type of veins, i.e. those in the Tertiary rocks we have many famous gold mines. There are veins in both the sedimentary and eruptive rocks of the Tertiary age. The greater part of the mines which are now in working order in Japan belong to this type as shown in the following list.

(2.) Impregnations :—Many veinlets run irregularly and form the network of ore deposition. This denotes undoubtedly the transition stage between veins and metasomatic deposits. There are two types of this form of deposition (a) Minute network in granite and (b) Impregnation in the Tertiary tuff, shale or in liparite. The former is the hair like minute veintets or ferruginous network in granite. These networks seem to enter the spaces between each constituent mineral of the rock and even enter into the cleavages of feldsper and mica so that when the granite is decomposed and becomes loose sand, the gold found therein will probably be mistaken for an original constiuent of this eruptive rock. The granite of the environs of Takahata mine in Rikuzen is a typical example.

Of the latter type there are a large number of mines especially in the dykes or bosses of liparite. Owing to the highly acidic and siliceous character of the rock, it is frequently supposed to be a large vein or mass instead of an impregnation of the rock. This type of deposit very often accompanies copper ores which have a tendency to increase in size with their depth. Poropets in Hokkaidō and Washinosu in Rikuchū are the important mines of this type.

(3.) Metasomatic deposits: — These are formed usually just on or near the periphery of an eruptive rock or even in that eruptive rock itself. The deposit is often associated with copper ores as in the case of impregnation. Kinkwaseki in Formosa is a typical mine.

(4.) Contact-metamorphic deposits:—The deposit of this type rarely occurs in the contract zone between Paleozoic limestone and some eruptive rock such as granite. Strictly speaking it is an auriferous copper or auriferous iron deposit. Ōta in Nagato and Rokuromi in Rikuchū are the examples.

(5.) Detrial deposits:—From early times many placer workings have been carried on in the river-beds or terraces along the river-sides in the districts of Kesen, Wakuya, Hayakawa, Abekawa, Yoshinogawa, etc. Recently they have begun to be worked in many localities in the Hokkaidō and the river Kilung in Formosa. Up to the present time only the surface placers have received attention, for which reason, no gold dredging or underground working has been attempted. The largest nugget ever found in Japan weighed only 27.1 ounces, and was found in the gold bearing gravel at Yesashi. The greater part of these deposits are in the Alluvium, while a few of them are discovered in the Dilnvium, yet we never find any Tertiary placers.

Now on tabulating the chief mines and localities of the mountain gold with their geological relations we find that they are as follows:—

| Mines. | Provinces. | Deposits. | Geology. |
|---|---|---|---|
| Zuihō | Formosa | Vein. | Tertiaries. |
| Kago | Satsuma | ,, | Mesozoics, andesite and liparite. |
| Ōtani | ,, | ,, | Liparite & Tertiaries. |
| Serigano | ,, | ,, | Andesite. |
| Yamagano | ,, | ,, | ,, |
| Ushio & Ōkuchi | ,, | ,, | ,, |
| Hoshino | Chikugo | ,, | ,, |
| Taiōno | Bungo | ,, | ,, |
| Mizobe | Buzen | ,, | ,, |
| Hasami | Hizen | ,, | Tertiaries & liparite. |
| Ōmatsuyama and its environs | Idzu | ,, | Liparite & andesite. |
| Nishizawa | Shimotsuke | ,, | Liparite, |
| Shōkawa districts | Hida | ,, | Liparite, mesozoics, and gneiss. |
| Hashidate | Echigo | ,, | Crystalline schists. |
| Sado | Sado | ,, | Tertiaries & andesite. |
| Shishiori | Rikuzen | ,, | Paleozoics. |
| Shiribeshi | Hokkaidō | ,, | Tertiaries. |
| Kusu | Bungo | Impregnation | Tertiaries and andesite. |
| Takahata and its environs | Rikuzen | ,, | Granite. |
| Washinosu | Rikuchū | ,, | Liparite & Tertiaries. |
| Ōkura | Uzen | ,, | ,, ,, |
| Tsugaru and its environs | Mutsu | ,, | ,, ,, |
| Porpets | Hokkaidō | ,, | ,, ,, |
| Kinkwaseki | Formosa | Metasomatic deposit | Dacite. |
| Botankō | ,, | ,, | ,, |

As a whole, the sedimentary and the eruptive rocks of the Tertiary age are the principal sources of gold in Japan. It is interesting to notice the fact that the greater part of this metal found in foreign countries comes on the contrary from quite a different source namely the rocks of the older formations. Next, let us take into consideration the detrial placers, we have:

| Localities. | Provinces. | Original Rocks and Deposits. |
|---|---|---|
| The River Kilung | Formosa | Veins and simple metasomatic deposits in decite and Tertiaries |
| The River Yoshino | Awa and Tosa | Veins in crystalline schists. |
| The River Abe, Ōi, and Haya. | Suruga and Kai | Veins in Paleozoics. |

| | | |
|---|---|---|
| River Shō. | Hida | Veins in liparite, Mesozoics and gneiss. |
| The River Setamai and the Bay of Hirota. | Rikuchū | Veins in Paleozoics and granite. |
| Yesashi. | Hokkaidō | Veins in Paleozoics. |

Geographical Distributions:—Although in small quantities gold is widely distributed, yet the chief gold producing regions are comparatively restricted to the small area of the following three regions i.e. (1) The northern corner of Formosa, (1) Several districts in Kyūshū especially in the province of Satsuma, and (3) The several districts of the north-eastern part of Honshū including the Island of Sado.

In Formosa there are three famous mines namely Kinkwaseki, Zuihō and Botankō which are being worked side by side in a small area of the district of Kilung. They are each, in fact, to be classed among the largest producers of gold in Japan. Almost the whole area of the province of Satsuma is ore-bearing. There are many mines which have been worked from the most ancient times. The mines of Yamagano, Serigano, Ushio, Ōkuchi and Kago are the most famous ones, but some of them are now in a doubtful stage with respect to their future prospects. Among other localities in Kyūshū, the most prominent mine is Hasami which is growing now in power of production and undoubtedly not a few years later will be one of the largest gold producers. In the Island of Shikoku and the whole western part of Honshū, there are scarcely any remarkable gold mines. The provinces of Idzu, Kai, Hida, Noto, Kaga, Tajima exist now as small pcoducers.

In the north-eastern part of Honshū many new localities have been lately discovered, though the most of them are now working without prcduction, but their prospects seem to be hopeful in the future As mentioned in the former list, there are extensive deposits and examples of impregnation in lipartite or Tertiary tuff although most of them are of naturally low-grade ores.

In Hokkaidō, the means of prospecting are very insufficient and only a few localities are known. During the five years from 1899 to 1904 the placer workings in this province were exceedingly prosperous especially after the discovery of the Yesashi, but that condition lasted for only a few years.

In Sakhalin, there are a few localities where placer work was at one time carried on in the regions of the Paleozoic formations. They are all at present suspended.

In short, when we consider this distribution geologically, we find that almost all the important localities of gold deposits at present are restricted to the Inner Side of the North and South Japan Arc, with the two volcanic zones of Kirishima and Fuji. On the other hand, the Outer Side of the Arcs, numerous veins which are not worked now, are in the Pre-Tertiaries together with their placers. This generalization coincides with the fact that in the Inner Side of the Arc many neo-volcanic rocks, which are the chief sources of the deposits, are developed, while in the Outer Side they have but little occurrenee.

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## SILVER.

History and Develepment:—In the year 674 A.D. silver was discovered at Sasu in Tsushima which is the oldest silver mine of which any historical data are recorded, but it has now become a zinc mine the silver working being abandoned. Three famous mines denominated respectively Handa, Ikuno, and Hosokura were found at the beginning of the 9th Century. Many other mines were in operation during about a hundred years from the end of the 16th Century. Recently, that is to say, in the decade from 1888—1897 inclusive, six principal deposits of silver were discovered on or near the coast lines of Kyūshū, Honshū and the Hokkaidō. But, since 1896, many silver mines have been obliged to close up their work on account of the great decline in the price of silver, such as for example: in 1896, the mines in Midzusawa and Karuizawa; in 1899, those in Mukōyama in Ani, Tagonai, Shiroyama, Ōmaki, Hachimori, Kuromori and Hirayu; during 1901—1902, those in Hata, Hosokura, Ikumi, etc.

The prcduction of silver has increased very slowly for 16 years from 1874—1889, and during 15 years after the year 1890 the yearly prcduction was nearly stationary with only a small fluctuation, notwithstanding the rapid progress of the gold and copper industries.

Since 1905 the production has been rapidly increasing due to the sudden development of Kosaka and lately with the addition of the great output of the Tsubaki mine. During the year 1908 the output of silver was 3,798,996 troy ounces valued at £430,055 occupying the 5th rank among the mineral products in Japan.

The outputs of the principal mines during 1907—1908 were as follows:—

| Mines. | Provinces. | 1908. (in Troy oz.) | 1907. (in Troy oz.) |
|---|---|---|---|
| Tsubaki | Ugo | 1,244,572 | 444,112 |
| Kosaka | Rikuchū | 1,110,707 | 1,119,656 |
| Ikuno | Tajim | 211,865 | 176,524 |
| Kamioka | Hida | 169,529 | 161,109 |
| Sado | Sado | 113,652 | 116,991 |
| Omori | Iwami | 96,153 | 73,580 |
| Innai | Ugo | 94 758 | 145,512 |
| Kanō | Iwashiro | 91,624 | 49,587 |
| Ashio | Shimotsuke | 75,082 | 48,993 |
| Yoshioka | Bitchū | 60,590 | 61,419 |
| Ani | Ugo | 44,943 | 54,100 |
| Hiragane | Hida | 38,996 | 47,083 |
| Kuratani | Kaga | 38,535 | 35,247 |
| Hisanichi | Ugo | 34,508 | 36,238 |
| Kinkwaseki | Formosa | 25,558 | 8,428 |
| Omodani | Echizen | 28,689 | 34,812 |
| Yamagano | Satsuma | 26,735 | 7,693 |
| Hatasa | Mino | 25,328 | 20,998 |
| Osaruzawa | Ugo | 25,219 | 26,334 |
| Bezaiten | Satsuma | 24,271 | 27,733 |
| Handa | Iwashiro | 21,249 | 20,175 |
| Hitachi | Hitachi | 30,615 | 501 |
| Kuki | Iwami | 20,291 | 40,906 |

The Augustin process was at one time the most commonly adopted among the wet methods for the extraction of silver. This process became quite popular and reached a high state of development, but it was afterwards superseded by the Patera and soon after by the Kiss process. Even now the last named process is used at the Ikuno mine. A few mines employed the process of amalgamation but now the Bezaiten is the only remaining silver mine which continues this process.

As for dry methods for the extraction of silver, lead was formerly used as the carrier of silver. But now in the smelters of Japan, copper seems to displace lead as a vehicle for the concentration of silver and gold, so that many silver mines have changed their metallurgical treatment and have introduced copper smelting furnaces. It is the most recent improvement in the metallurgy of copper to increase the quantity of gold and silver.

Kinds of Ores:—The normal ores of silver in Japan are argentite, stephanite, pyrargyrite, etc., but such minerals as galena, tetrahedrite, chalcopyrite, etc. are very often argentiferous and practically give greater supplies of silver.

According to the statistic, the production of the twenty principal mines during the last five years aggregates 85.2% of the total output of silver in this country. Among them the greater amount of the silver comes from the argentiferous lead ore and the remaining part from the normal or dry silver ore and the argentiferous copper ore i e. 65.7% from the argentiferous lead ore, 18.6% from the normal or dry silver ore and 15.7% from the argentiferous copper ore, while the output of silver derived from copper ore has a tendency to overcome that from the normal or dry silver ore.

Deposits and Geology:—The deposits of silver are as follows,

(1.) Fissure filling or veins.
(2.) Impregnations.
(3.) Metasomatic deposits.
(4.) Contact-metamorphic deposits.

(1.) Veins:—There are many principal mines belonging to this class. Among them the three kinds of silver ores above mentioned are equally developed and the greater part of the mines is in the rocks of both the eruptive and sedimentary classes of the Tertiary age quite as in the case of gold.

(2.) Impregnations:—A few mines of this class are known, but they have little importance in the production of silver at present. They are all ranged in the Tertiary rocks as in the case of gold. There are a few examples of the deposits of argentiferous lead or copper ore, but any case of the dry silver ore type has not yet been found. Fukuishi at Ōmori in Iwami, and the ores of Matsuoka and Hata in Ugo are the typical examples.

(3.) Metasomatic deposits:—The so-called Kurokō deposit is the only ore belonging to this class. There are great numbers of this class of deposits which have not yet been explored. Their gossan or the oxidized ore resulting from the decomposition of galena, zincblende and often from pyrite, are treated as silver ores, but with regard to the unaltered Kurokō itself, Tsubaki being the only working mine for silver which has the largest output of this metal in Japan.

(4.) Contact-metamorphic deposits:—In this class there is no deposit of the dry silver ore type as in the above two cases. There are large numbers of these mines but only a few of them are important such as those at Kamioka and Hiragane in Hida. Their occurrence is very common at the contact or near the point of contact of eruptive rock and Paleozoic or Archaean strata.

In short, the silver deposits in veins and those of impregnation and metasomatic type come for the most part from the neo-volcanic rocks such as the andesite and the liparite, and the Tertiaries. On the other hand, the types of contact-metamorphic are restricted to the region of the Pre-Tertiary rocks.

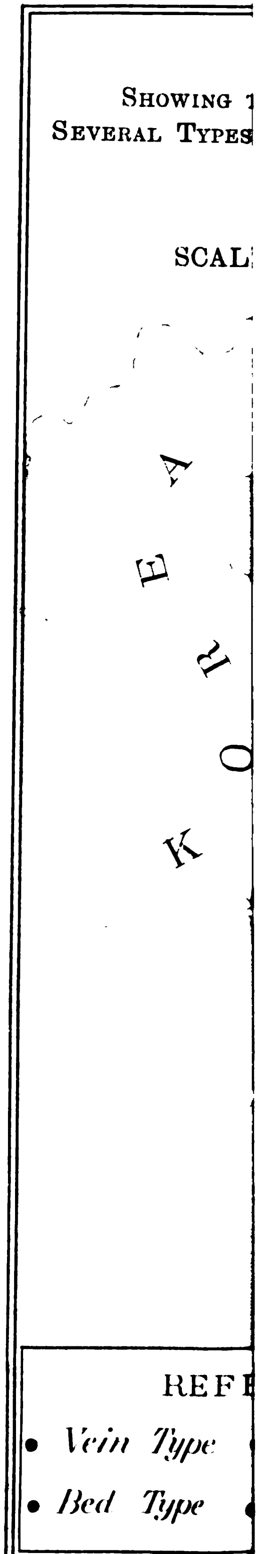
If we tabulate the 20 principal mines of silver, we have:—

| Mines. | Provinces. | Kinds of ore. | Kinds of deposits. | Geology. |
|---|---|---|---|---|
| Bezaiten | Satsuma | Ag. | Veins. | Liparite. |
| Kuki | Iwami | Ag. Pb. | ,, | ,, |
| Yeikyū, Ōmori | ,, | Ag. Cu. | ,, | Andesite and Tertiaries. |
| Kanagase, Ikuno | Tajima | Ag. Cu. | ,, | Liparite |
| Tasei, Ikuno | ,, | Ag. | ,, | ,, |
| Tada | Settsu | Ag. Cu. | ,, | Liparite and Paleozoics |
| Hatasa | Mino | Ag. Pb. | ,, | Liparite. |
| Kuratani | Kaga | Ag. Pb. | ,, | Tertiaries and liparite. |
| Handa | Iwashiro | Ag. | ,, | ,, |
| Hosokura | Rikuzen | Ag. Pb. | ,, | Tertiaries and andesite. |
| Innai | Ugo | Ag. | ,, | Andesite, liparite and Tertiaries. |
| Todoroki | Hokkaidō | Ag. | ,, | Tertiaries and liparite. |
| Shikaripets | ,, | Ag. Pb | ,, | Tertiaries. |
| Ōmori (Fukuishi) | Iwami | Ag. Cu. | Impregnations | Andesite and breccia. |
| Karuizawa | Iwashiro | Ag. Pb. | ,, | Liparite. |
| Matsuoka | Ugo | Ag. Pb. | ,, | Tertiaries and liparite. |
| Tagonai | ,, | ,, | ,, | ,, |
| Tsubaki | ,, | ,, | Metasomatic | Tertiaries and andesite. |
| Kamioka | Hida | ,, | Contact-metamorphic | Gneiss and quartzporphry. |

Geological Distribution.—Almost all the known localities of silver ore are confined to Honshū and a few of them are found in the province of Satsuma in Kyūshū and the western part of the Hokkaidō. In Formosa and in the Island of Shikoku no silver deposit has as yet been found. In the southern part of Satsuma there are small mines of the normal, or dry silver ore type highly charged with gold, but toward the northern part, the quantity of gold increases and argentiferous gold mines are found such as those in Serigano, Hashima, etc. In the western part of Honshū, mines are situated in the provinces of Iwami, Idzumo, Bitchū, Tajima, Settsu, Echizen, Mino, Hida, etc., along the coasts of the Japan Sea. In the north-eastern district, they have developed in a similar manner and there many famous mines are situated, though a large number of them are now in a state of inactivity. In the province of Ugo many argentiferous galena mines are grouped, but all of them except Tsubaki and Innai have been obliged to cease operations on account of the great decline in the price of silver. In the Hokkaidō, there are large deposits of silver at Todoroki and Shikaripets not to mention other small mines. These are however all of quite minor importance at present.

In short, reference to a geological map will show that nearly the whole of the mines are situated in the Inner Side of the North and South Japan Arc, while a few of them are in the volcanic zone of Kirishima. No silver mine has ever been found in the Outer Side. Such a distribution of the mines is due to the development of the neo-volcanic rocks which are the chief source of this metal as they are also of gold.

PLATE I.



# COPPER.

History and Development:—In Japan copper was known from the earliest times, the oldest mine which is now in active operation being the Osaruzawa, discovered about 1200 years ago. Yoshioka and Ikuno are the next at the date of 807 A.D. Many other principal mines have been opened since the 14th Century especially and a large number in the 17th Century. During about a hundred years before the Restoration, there were no remarkable discoveries of mines, but during the last 30 years many deposits have been discoverd particularly in the pyritic beds in the crystalline schists and other older formations. On the other hand, several mines which were abandoned in consequence of too low tonor of ore or on account of the difficulties of mining, have been re-opened. In consequence of this revival, the production of copper is regularly and steadily increasing so that it has now really grown to be the most important metallic product of exportation.

The output of copper during 1908 amounted to 40,441 long tons valued at £2,294,265 which is on increase of 4,543 long tons but decrease of £617,141 in value on comparison to those of the previous year, owing to the great decline in the price of copper. The output was 21.9 % of the total for and 1098 occupies the second rank among the mineral products in Japan. The outputs of the important mines 1907—1908 during are given in the subjoined table:—

| Mines. | Provinces. | 1908. (In long tons.) | 1907. (In long tons.) |
|---|---|---|---|
| Kosaka | Rikuchu | 7,086 | 8,215 |
| Ashio | Shimotsuke | 6,972 | 6,262 |
| Besshi | Iyo | 5,173 | 5,347 |
| Hitachi | Hitachi | 1,871 | 787 |
| Osaruzawa | Rikuchū | 1,358 | 1,174 |
| Ani | Ugo | 1,284 | 1,174 |
| Ikuno | Tajima | 1,152 | 856 |
| Kanō | Iwashiro | 974 | 237 |
| Hibira | Hyūga | 870 | 847 |
| Yoshioka | Bitchū | 778 | 846 |
| Obiye | ,, | 736 | 696 |
| Arakawa | Ugo | 732 | 714 |
| Hisanichi | ,, | 689 | 685 |
| Ogoya | Kaga | 685 | 637 |
| Yūsenji | ,, | 610 | 429 |
| Furokura | Ugo | 578 | 457 |

| | | | |
|---|---|---|---|
| Makimine | Hyūga | 542 | 530 |
| Hiragane | Hida | 510 | 614 |
| Kinkwaseki | Formosa | 319 | 46 |
| Ōmori | Iwami | 314 | 267 |
| Tokitō | Rikuchū | 279 | — |
| Tsubaki | Ugo | 274 | 86 |
| Hōmanzan | Idzumo | 271 | 313 |
| Nagamatsu | Uzen | 259 | 273 |
| Midzusawa | Rikuchū | 256 | 207 |
| Kusakura | Echigo | 238 | 296 |
| Omodani | Echizen | 183 | 227 |
| Chihara | Iyo | 170 | 62 |
| Innai | Uzen | 153 | 260 |
| Sasagatani | Iwami | 144 | 135 |
| Takane | Hida | 142 | 103 |
| Ōtori | Uzen | 123 | 118 |
| Kokusei | Mimasaka | 117 | 88 |
| Yaguki | Iwaki | 113 | 176 |
| Takara | Kai | 110 | 144 |

The export of copper commands the largest value in the mineral output in Japan and in the year 1908 it occupied 50.2 % of the total against 57.2 % in 1907. The exports in 1908 amounted to 35,929 long tons (89.5 % of the total domestic production of copper in the same year) valued at £2,157,764 which was an increase of 4,096 long tons but a decrease of £789,999 in values from the previous year. The quantity of slabs and ingots exported from Kobe, Yokohama, and Ōsaka wereas follows:—

| | 1908. | | 1907. | |
|---|---|---|---|---|
| Countries | Quantity (in long tons.) | Value. | Quantity (in long tons.) | Value. |
| England | 10,157 | £616,388 | 4,964 | £451,472 |
| Hongkong | 7,505 | 410,947 | 5,079 | 478,289 |
| America | 5,540 | 330,849 | 3,534 | 309,668 |
| France | 3,540 | 227,351 | 2,732 | 236,427 |
| China | 2,406 | 156,351 | 10,325 | 972,676 |
| India | 2,412 | 150,754 | 289 | 20,963 |
| Germany | 2,047 | 115,660 | 2,490 | 230,992 |
| Austria | 818 | 47,844 | 737 | 68,663 |
| Korea | 226 | 15,120 | 99 | ,864 |
| Kantung province | 71 | 4,477 | 496 | 58,414 |
| Italy | 50 | 3,400 | 577 | 53,886 |
| Straits Settlements | 48 | 2,942 | 6 | 460 |
| Others | 1,046 | 75,682 | 539 | 56,990 |
| Total | 35,866 | 2,157,765 | 31,777 | 2,947,764 |

A small amount of copper was imported annually as:—

| Name | 1906. Quantity (In long tons.) | 1906. Value | 1907. Quantity (In long tons. | 1907. Value |
|---|---|---|---|---|
| Slabs and ingots | 150 | £5,870 | 125 | £5 384 |
| Plates and loads | 259 | 20,701 | 178 | 19,587 |
| Wires | 45 | 3,958 | 13 | 1,662 |
| Tubes and pipes | 558 | 54,762 | 560 | 67,797 |
| Total | 1,012 | 85,291 | 876 | 94,430 |

The "Kurokō" deposit which was formerly worked with more special attention to its gossan has recently excited interest in its rejected sulphides found in ores below the surface since the success at Kosaka mine. The regions of the pyritic beds are mountainous owing to the older geological formations and have suffered the disadvantage of the transportation of the ore to the nearest railway-station or seaport. On account of this inconvenience and the insufficiency of the prospecting up to the present this deposit seems to give a reasonable hope of being more prosperous in the near future. Together with such basic ores, the cupriferous gold or silver ore must be necessarily utilized and practically the development of such ores is progressing at present by leaps and bounds.

Most of the early copper mines were worked for the richer grade of ores, without any consideration of the subsequent development of the mine at greater depths. In consequence of this short-sighted policy it followed that the mines were generally closed down when the rich ores of the upper levels gave place to the lower grades of sulphides below. At the present day, however, the working process is systematized and avoiding such an unscientific method and the scale is enlarged by utilizing the electric power instead of hand or steam power.

In the old process the ores were roasted before being smelted, which required a great consumption of fuel and in addition an extra operation. About nine years ago pyritic smelting was first introduced at Kosaka, which opened up a new era of prosperity for the copper mining industry in Japan. Nowadays the mines of Hitachi and Kano are following this method. When the ore is not absolutely suitable for this purpose it may be treated by means of partial pyritic smelting. Many principal mines such as those at Ashio, Osaruzawa, etc., have adopted this process. The process of electric refining has advanced considerably especially by reason of its practical utility in the collecting of gold and silver on the one hand and in the purifying of copper on the other. The noble metals which were formerly lost on account of their combination in the crude copper, can now be saved even if they form but a small percentage of the entire mass. This improvement undoubtedly increases the total sum of the production of the noble metals. The Kosaka mine, the Nikkō and Ōsaka refining works are places of importance to be remembered in this connection.

Thus it will be seen that low grade ores, containing but a small proportion of gold and silver, can now, if occurring in large deposits, be profitably treated. At present, there is a tendency to look more attentively at the quantity than at the quality.

Kinds of Ores:—The principal ores of copper are chalcopyrite and bornite, rarely tetrahedrite and energite, together with the secondary minerals as malachite, chrysocolla, bornite, chalcocite, etc. Their gangues are quartz or calcite rarely baryte, fluorite or siderite. In some kinds of deposits almost the whole part of the gangue is composed of baryte or the so-called contact minerals such as garnet, pyroxene, amphibole, epidote, etc. In other cases they are all absent.

Deposits and Geology: — Deposits of copper ore occur in Japan as:

(1). Fissure filling or veins.
(2). Impregnations.
(3). Metasomatic deposits.
(4). Contact-metamorphic deposits.
(5). Sedimentary deposits from chemical precipitation or the so-called bed.

(1) Veins ;—In this class large numbers of the principal mines are included. The ores are commonly acidic owing to the development of quartz or fragments of the country rocks. They are more or less auriferous or argentiferous or both. Besides these impurities many other metallic minerals such as pyrite, blende, galena, arsenopyrite are the common associated minerals. The deposits occur in both the sedimentary and the eruptive rocks of the Tertiary and Pre-Tertiary ages, but the majority of it is in the rocks of the former age.

(2) Impregnations :— A few deposits occur in the Tertiary rocks. They were treated already in the case of gold, but they are less important as copper deposits.

(3) Metasomatic deposits :—These deposits are represented by "Kurokō" which is a complex sulphide ore consisting of the intimate mixture of galena, zincblende, and baryte and commonly forms irregular masses in the eruptive contact. They shall be described hereafter under special sub-titles.

(4) Contact-metamophic deposits:—There are two types as:— (a) Deposits in the eruptive contact, (b) Deposits in granite or granitoid rocks. The former deposits are characterized by the gangue minerals of pyroxene, amphibole, garnet, epidote, etc. These deposits are abundant but comparatively less important compared with those of other classes. They occur more usually in limestone along the eruptive contact. Pyrrhotite, pyrite, zincblende, galena, arsenopyrite sometimes magnetite, and hematite are the chief associates of chalcopyrite. The greater part of these deposits are found in the Paleozoics and the remaining parts are in the Archaean and Mesozoic rocks but are never found in the Tertiaries.

The latter type of metamorphic deposits is characterized by its occurrence in granite or ganitoid rocks. Their principal gangues are mica, which is perhaps derived from the altered product of feldspar in granite. In this case the country rock, near to the deposit becomes greisen i.e. a granular admixture of quartz and mica both primary and secondary. There are only a few examples, and they are of but minor importance as copper producers. In Takayama in Aki, and in Kōyei in Bingo are found typical examples of this form of deposits.

(5) Beds.—These are pod or lens-shaped deposits in crystalline schists, in the Paleozoic and Mesozoic strata, but theyare never found in the gneissic formations or in the Tertiaries. It is a noticeable fact that they never cut the plane of sedimentation, or are associated with any eruptive rock which is common in the metasomatic and metamorphic types. It is yet an unsolved problem as to whether the deposits are true beds or not. The ore is massive, and the pyrite usually contains but a low percentage of copper and is very often associated with pyrrhotite or magnetite. The ore therefore is commonly highly basic, frequently containing small quantities of quartz and calcite.

In short, the deposits of copper ore are well distributed in each geological formation except the Quaternary strata only. Moreover, for different kinds of deposits, there are also different kinds of ores, i.e. in such deposits as veins and impregnations, the ores are generally acidic while the metasomatic and bed ores are basic, but the contact-metamorphic ores are commonly neutral or self-fluxing.

The relations between deposits, country rocks, etc., of the principal mines in Japan which have hitherto been worked with profit are as follows:—

| Mines. | Provinces. | Deposits. | Geology. | Distribution. |
|---|---|---|---|---|
| Obiye | Bizen | Vein | Paleozoics near granite | South Japan, Inner Side. |
| Yoshioka | Bitchū | ,, | Paleozoics near porphyrite. | ,, |
| Ōmori | Iwami | ,, | Tertiaries and andesite | ,, |
| Hōmanzan | Idzumo | ,, | Tertiaries and liparite | ,, |
| Kanagase, Ikuno | Tajima | ,, | Liparite | ,, |
| Omodani | Echizen | ,, | ,, | ,, |
| Yūsenji | Kaga | ,, | Tertiaries | ,, |
| Ogoya | ,, | ,, | ,, | ,, |
| Kusakura | Echigo | ,, | Tertiaries and andesite | North Japan, Inner Side. |
| Nagamatsu | Uzen | ,, | Tertiaries | ,, |
| Ōtori | ,, | ,, | ,, | ,, |
| Arakawa | Ugo | ,, | Tertiaries and andesite | ,, |
| Hisanichi | ,, | ,, | Tertiaries | ,, |
| Ani | ,, | ,, | ,, | ,, |
| Ashio | Shimotsuke | ,, | Liparite | ,, |
| Midzusawa | Rikuchū | ,, | Gneiss | ,, |
| Osaruzawa | ,, | ,, | Tertiaries | ,, |
| Takara | Kai | Metasomatic | Tertiaries and liparite | North Japan, Outer Side. |
| Kanō | Iwashiro | ,, | ,, | North Japan, Inner Side. |
| Kosaka | Rikuchū | ,, | ,, | ,, |
| Ōta | Nagato | Contact-metamorphic | Paleozoic limestone and granite | South Japan, Inner Side. |
| Kitsunezuka and its environs | ,, | ,, | Paleozoic limestone and andesite or liparite | ,, |
| Sasagatani | Iwami | ,, | Paleozoic limestone and liparite | ,, |
| Mihara | Bitchu | Contact-metamorphic | Mesozoic limestone and quartz-porphyry | South Japan, Inner Side. |
| Takane | Hida | ,, | Paleozoics and quartz-porphyry | ,, |
| Hiragane | ,, | ,, | Paleozoics and andesite | ,, |

| | | | | |
|---|---|---|---|---|
| Yakuki | Iwaki | ,, | Paleozoic limestone and quartz-porphyry or diorite | North Japan, Outer Side. |
| Hibira | Hyūga | Bed | Paleozoics | South Japan, Outer Side. |
| Makimine | ,, | ,, | ,, | ,, |
| Chibara | Iyo | ,, | Crystalline schists | ,, |
| Nishinokawa | ,, | ,, | ,, | ,, |
| Besshi | ,, | ,, | ,, | ,, |
| Mochibe | Awa | ,, | ,, | ,, |
| Iimori | Kii | ,, | ,, | ,, |
| Kune | Tōtōmi | ,, | ,, | ,, |
| Kokusei | Mimasaka | ,, | Paleozoics | South Japan, Inner Side. |
| Hitachi | Hitachi | ,, | ,, | North Japan, Outer Side. |

Geographical Distribution:—The deposits of copper ore are among the most important and the most widely distributed in Japan. They are well equally distributed in Honshū, Shikoku and Kyūshū, while in Formosa and Hokkaidō, there are nothing but a few localities of less importance. The four important types which are spread over Japan exist in beds, metasomatic deposits, contact-metamorphic deposits and veins.

Generally speaking, these different kinds of deposits are developed in the different regions in connection with the different geological formations. They have, so to speak, spheres of influence for each region i.e. the Outer Side of the North and South Japan Arc is the only region where the bed type prevails so that along this zone especially on the South Japan Arc many principal mines are located. For the Inner Side, the deposits of the remaining three types are intermixed. But, in general, the contact-metamorphic type exerts its principal influence in the South Japan Arc, while the type of the metasomatic prevails in the North Japan Arc. Moreover, the vein type spreads over the whole region of the Inner Side as shown in the following map. The reason can be easily demonstrated; when we examine the geological map of Japan, we find in the Outer Side of the Japan Arc, crystalline schists, Paleozoic and Mesozoic strata are developed. But in South Japan Arc along the Inner Side, great masses of granite which chiefly cause contact metamorphism upon the Paleozoics, sometimes gneiss or Mesozoics, are well developed, while in the North Japan region Tertiaries and neo-volcanics prevail. As has been formerly stated, these sedimentaries and eruptives of each formation are indeed the chief indigenous rocks in which each kind of deposit has its habit.

Lastly, when we examine the copper production of the 53 principal mines during the last five years, (which amounts to 86.6% of the total production in Japan), we have the following results:

| Types of deposits. | No. of mines. | Percentage of the relative production |
|---|---|---|
| Veins | 32 | 44.8 |
| Beds | 11 | 20.8 |
| Metasomatic deposits | 3 | 18.0 |
| Contact-metamorphic deposits | 7 | 3.0 |

In this list, the production of the six principal mines belonging in the bed type are omitted, because they are sold directly to the alkali works and other purchasers, and after their utilization as sulphur ore they are smelted. The ores contain about 3% Cu. in the average. When they are added to the above calculation, the ratio of the percentage of the bed type will increase remarkably. The quantity of copper produced from this source may be about 2,430 long tons per year, so that the percentage ratio of the bed type above described should be increased to 26.6%.

## Kurokō.

Ore:—"Kurokō" is the name given to a peculiar sort of ore occurring in Japan. "Kuro" means black and "Kō," ore, whence the designation black ore. It is a remarkably homogenous and dense ore, consisting of an intimate mixture of barite, zincblende, and galena often containing pyrites and chalcopyrites as accessories. The color varies, according to the predominance of the several ingredients. As the blende is ferriferous and almost black, it imparts a dark color to the ore, while the galena imparts a gray, and the pyrites a yellow tint. When however barite is the predominant constituent, the ore may look almost white. The gold and silver found in this "kurokō" ore are of important nature. The carrier of the former is perhaps the pyrite, while the latter seems to be contained in the galena.

When "kurokō" oxidizes by the influence of the weather, the "Dokō" (earthy ore) is the result produced, showing various colors such as yellow, brown, green, red, white, or gray. They are caused by the mixture of the secondary minerals of blende, galena, pyrites, chalcopyrites and unaltered barite respectively. This zone of oxidation has been enriched by gold and silver with lead, and a little below this zone, there lies the zone of copper enrichment. Thus this kurokō ore was formerly worked out, as a silver one or rather it might be more properly stated that the parts exposed to the weather were thus worked. However in the zone of the unaltered kurokō itself, the relatively poor content of silver, and the difficulty of metallurgy caused many mines of such a nature to be abandoned. When fortunately the kuroko contains a tolerable quantity of chalcopyrites, the unaltered ore can be treated as a copper ore in the manner customary in Kosaka in Rikuchū and Kanō in Iwashiro. Thus the former silver mine becomes changed to a copper mine.

The following list is the total analyses of kurokō which are treated in several mines:—

| | Au | Ag | Cu | Pb | Zn |
|---|---|---|---|---|---|
| No. 1 ... ... | 0.000158 | 0.0187 | 2.39 | 2.41 | 12.64 |
| No 2 ... ... | — | 0.99 | Trace | 0.66 | 1.55 |
| No. 3 ... ... | 0.00012 | 0.0236 | 3.50 | 3.60 | 20.96 |

| Fe | $SiO_2$ | $Al_2O_3$ | S | $BaSO_4$ | $BaCO_3$ |
|---|---|---|---|---|---|
| 11.69 | 5.25 | 3.10 | 20.85 | 39.98 | — |
| 2.65 | 35.47 | 4.63 | 2.75 | 46.28 | 3.75 |
| 10.16 | 21.14 | 6.98 | 17.48 | 17.54 | — |

No. 1 is the average amount of ores of Kosaka mine treated during 1905, No. 2 is that of Tsubaki mine during 10 days October, 1906, and No. 3 is that of Kanō mine during the first half year of 1908.

In addition, the following list is the analyses of the oxidized ore in Kosaka:—

| | Au | Ag | Cu | Pb | Zn |
|---|---|---|---|---|---|
| No. 4 ... ... | 0.000171 | 0.0201 | 0.457 | 2.189 | 0.499 |
| No. 5 ... ... | — | 0.0246 | 0.574 | 2.117 | 0.571 |
| No. 6 ... ... | 0.000072 | 0.1114 | 6.300 | 1.222 | 11.210 |

| Fe | $SiO_2$ | $Al_2O_3$ | S | $BaSO_4$ |
|---|---|---|---|---|
| 10.884 | 19.379 | 6.210 | 1.742 | 49.795 |
| 7.172 | 30.082 | 4.781 | 1.441 | 44.942 |
| 11.692 | 3.116 | 1.490 | 24.846 | 36.128 |

No. 4 and No. 5 are the analyses of "Dokō" (earthy ore), which show the powder and the lump ores treated during 1894—1898 respectively, and No. 6 is that of copper enriched zone directly under the earthy ore treated during 5 months in 1899.

Deposit:—The formation of the kurokō is by means of a metasomatosis, without any metamorphism by contact with the adjacent rock. The ore varies greatly in form, some specimens of which are quite irregular, but it is usually thicker above and thinner below, while other specimens look like big potatoes with their buds downward. Some are like inverted flasks, some are wedge-shaped and others are sheet-like or sometimes an assemblage of ore nodules is arranged in a zone.

The deposit is sometimes associated with a large deposit of pyrites or a siliceous pyrite mass, both of which are usually cupriferous and also contain small quantities of gold and silver similar to the kurokō ore. These often envelope the kurokō deposits and at the first glance they may seem to be of a later origin, but in reality they are older. These pyrites or siliceous pyritic ores are quite useful as fluxes for the smeltingof kurokō.

Geology:—This deposit is restricted to the Tertiary region, being always found at the contact of the sedimentaries with the volcanics namely liparite and andesite and intrusive in them. The latter is not porphyritic as in its younger facies, but diabasic and often entirely porphyritized. When both of the volcanic rocks are present, we usually find the ore in only one of them. Among 36 examples, 24 are along the contact with the liparite, and the remaining are along that with the andesite. But the basicity of these two rocks seems to have no influence in the formation of the kurokō deposit. Sometimes, however, the deposit is in close proximity to the point of contact, the ore being either in the sedimentaries or in the volcanic rock. With regard to the sedimentary rocks, the more porous and soluble rocks are under more favourable conditions for the formation of the deposits. Among 35 cases, 17 are in tuffs and tuff breccias, 4 in tufaceous shales, and 14 in shales. Clay, gypsum, and various colored jasperoids are associated with the deposit, and serve, together with the barite outcrop, which is the residual product from the decomposition of kurokō, only as indicators for the prospecting purposes. For attaining the best results in exploration, the most important thing is to trace the volcanic rock that may be near by and more or less connected with the deposit.

Distribution:—Some 39 mines are known to exist in Japan, but only a few of them are in active operation at present. They are Kosaka, Tsubaki, Kanō, Ōishida and Kunitomi, Masukawa, Ainai, Tanosawa, Hanaoka, Yoshino, Karatoya, Takara and Tashiro. In the foreign countries we have as a few examples of this deposit, those in Vancouver. Island in Canada and on Mount Shasta in California, U.S. but in no other country does it show so wide a distribution as in Japan.

Among the kurokō mines the well known are as follows:—

| Mines. | Provinces. | Mines. | Provinces. |
|---|---|---|---|
| Kunitomi | Shiribeshi | Midzusawa | Ugo |
| Towada | Rikuchū | Magi | " |
| Kosaka | " | Karatoya | Uzen |
| Komagi | " | Yoshino | " |
| Tanosawa | " | Kanō | Iwashiro |
| Ōmaki | Ugo | Anogawa | Kōtsuke |
| Hanaoka | " | Takara | Kai |
| Tsubaki | " | Wanibuchi | Idzumo |

The deposits occur principally in the so-called Inner Side of the North and South Japan Arc, where we find Tertiary rocks very extensively developed, togeiher with volcanic rocks of younger dates. Still only two of them are found very near to the Fuji volcanic zone.

Genesis:—The irregular forms of the kurokō deposit, and the intimately mixed state of the constituent minerals must have been due to the sudden volatilization and condensation of the superheated fluid rising from the interior of the earth. The ore, which was produced by substances emanating at the eruption of the volcanic rocks, was naturally deposited near the contact of the magma with the sedimentaries intruded, thus partly in the volcanics and partly in the Tertiary rocks. By the action of the emanated substances upon the rocks of the locality, the jasperoids were produced from silica carried out in a soluble form; the gypsum, by the combination of sulphurous gases with the lime in the rocks; while the residual clay is the final remainder of the altered rocks. Whether the intrusion was acidic or basic, makes no essential difference, since by liparite and andesite carry the ore in quite the same manner.

The deposition seems to have taken place either at the end of the Tertiaries or at the beginning of the Diluvium. The outline of the deposit is interesting. The superheated fluid in rising to a higher level, was turned into a gaseous state by the reduction of pressure; and thus injected and dissolved, throughout a wide extent, the rocks coming in contact where the deposits of kurokō was formed. Thus the deposit is broad above and slender below. Sometimes at a still higher seat, or on the ouside of the deposit, the gaseous body formed true fissure-veins by passing into a liquid state on cooling, where is a differentiation of the constituent minerals is observed. At Tsubaki, there is a typical example, in which the veinlets are spread out from the main deposit, just like the arms of a crinoid from its calyx. Perhaps the stem corresponding to a narrow passage below of the superheated solution which formed the kurokō may be found in some later stage of excavation.

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## LEAD.

Lead mining has not been developed to any extent. The reason is that all the lead ores hitherto discovered contain silver in great or less proportion and it was only natural that those which were richest in silver should be the first to be worked. Hence the silver has been the principal metal sought for and the lead has been regarded as a useful accessory. The production of lead is slowly increasing year after year and has now become nearly 3,000 long tons annually. But it is too small to supply the domestic demand and the amount of about three or four times the output has been imported annually. Bullions were imported from the U. S. A., Australia, England and Canada but the manufactured goods such as plates, wires, tubes and tea-lead came entirely from England. The production of lead during 1908 was 2,900 long tons valued at £40,879 and the imports amounted to 8,386 long tons valued at £131,571. The output of the important mines during 1907—1908 were as follows:

| Mines. | Provinces. | 1908. (long tons.) | 1907. (long tons.) |
|---|---|---|---|
| Kamioka | Hida | 2,130 | 2,084 |
| Kosaka | Rikuchū | 372 | 542 |
| Kuratani | Kaga | 184 | 144 |
| Kuki | Iwami | 103 | 179 |
| Daira | Ugo | 46 | 22 |
| Hosokura | Rikuzen | 23 | 16 |
| Bandōjima | Yechizen | 3 | 4 |

Ores:—The principal ores of lead are galena rarely cerussite and anglesite.

Deposits:—Zincblende is the most common associate of galena, so that, the occurrence of lead is similar to that of zinc ore i.e. (1) Veins, (2) Metasomatic deposits and (3) Contact-metamorphic deposits.

The following is a list chief localities:—

| Mines. | Provinces. | Deposit. | Geology. |
|---|---|---|---|
| Daira | Ugo | Vein | Tertiaries and Andesite. |
| Hosokura | Rikuzen | ,, | ,, |
| Kuratani | Kaga | ,, | Tertiaries. |
| Hatasa | Mino | ,, | Liparite. |
| Kuki | Iwami | ,, | ,, |
| Kosaka | Rikuchū | Metasomatic deposit. | Tertiaries and Liparite. |
| Kamioka | Hida | Contact-metamorphic deposit. | Gneiss and limestone near quartz-porphyry |

Distribution:—The distribution is nearly similar to that of zinc ores, so that for the most part the deposits have been distributed along the Inner Side of the Japan Arc.

## ZINC.

The occurrence of zincblende is usually regarded as detrimental to the ores of copper and lead with which it is nearly always associated. Lately i.e. since 1905 it has been exported annually as:—

| | 1908. | 1907. | 1906. | 1905. |
|---|---|---|---|---|
| Quantity (in long tons) | 14,735 | 19,485 | 15,185 | 12,359 |
| Value | £49,027 | £59,891 | £47,789 | £26,491 |

The greater parts of these exports were shipped to Belgium and the rest to Hongkong, Germany and England.

The recognized standard or grade for marketable ore is 40% of zinc; but unfortunately much of the deposits contain less than this amount. If the processes of magnetic separation and flotation were as successful as in Kamioka mine, the values of many other mines would be greatly increased. The outputs of the important mines during 1907—1908 were as follows:—

| Mines. | Provinces. | 1908. (in long tons) | 1907. (in long tons) |
|---|---|---|---|
| Kamioka | Hida | 8,676 | 5,6[illegible]8 |
| Karatoya | Uzen | 2,755 | 2,208 |
| Sasu | Tsushima | 2,182 | 3,276 |
| Yoshino | Uzen | 713 | 4,115 |
| Kamegaya | Etchū | 280 | 226 |
| Uwomi | Echizen | 268 | 360 |
| Sano | Bizen | 134 | 51 |
| Yamaguchi | Iwashiro | 59 | 15 |
| Funachi | Mutsu | 45 | 145 |
| Wanibuchi | Idzumo | 20 | 1,465 |
| Sawa | Kaga | 5 | 421 |
| Kanahira | ,, | — | 141 |

Up to the present no attempt has been practically made to get metallic zinc and large quantities of this metal in the forms of slabs, ingots, plates, etc., are imported annually. Among them plates formed the largest item and in 1908 the total imports amounted to 8,776 long tons valued at £204,794. They were imported from Germany, Belgium and England.

Ores:—Zincblende is the most common ore of zinc and is found associated with galena and chalcopyrite. It is always very ferriferous and imparts a brownish black colour. Very rarely calamine and smithonite are found in the oxidized zone.

Deposits:—There are three kinds of occurrences, i.e. (1) Veins, (2) Metasomatic deposits and (3) Contact-metamorphic deposits. All of them are equally developed, but the most of the mines which produce the ore now belong to the second type. Their geological location is not confined to any one particular formation. It is distributed well from the Archean to the Tertiary era, but many of the deposits are included in the rocks, both of the Paleozonic and the Tertiary formations. The relation between the deposits and the geology of the principal mines are as follows:—

| Mines. | Provinces. | Deposit. | Geology. |
|---|---|---|---|
| Hosokura | Rikuzen | Vein | Tertiaries and Andesite. |
| Sasu | Tsushima | ,, | Mesozoics near quartz-porphyry. |
| Uwomi | Echizen | Metasomatic deposit. | Paleozoics. |
| Wanibuchi | Idzumo | ,, | Tertiaries near andesite. |

| | | | |
|---|---|---|---|
| Kanō | Iwashiro | Metasomatic deposit. | Tertiaries and liparite. |
| Karatoya | Uzen | „ | „ |
| Yoshino | „ | „ | „ |
| Kamioka | Hida | Contact-metamorphic deposits. | Gneiss and limestone near quartz-porphyry. |

Distribution:—Zincblende is one of the most widely distributed minerals in Japan. In the southern part of Bungo in Kyūshū high-grade ores are found in several regions, but none of them are operated owing to the difficulty of the transportation of the ores. On the island of Tsushima, the ores of Sasu the oldest silver mine in Japan, are noted for their good quality. Along the Japan Sea side of Honshū almost every province has the deposits of zinc ores especially abundant in the northern part. Among them the ores of Idzumo are barytic and of a low grade. In the provinces of Bizen, Bitchū and Mimasaka there are many deposits which are not yet opened. The provinces of Echizen, Kaga, Etchū, Mino and Hida form one of the centers of mining camps where many mines are now actively operated, and where besides them many other probable sources of zinc ore are hidden. Kamioka in Hida is the largest zinc mine and nowadays 1,000 tons of this ore containing 55% Zu are monthly produced. On the northern part along the Japan Sea in such districts as the provinces of Echigo, Uzen, Ugo, Mutsu, Iwashiro and Shimotsuke many deposits are now being opened and worked; some of them are highly barytic and of low grade, but many of them are of a good quality. Karatoya, Yoshino, Kanō and Hosokura are the largest mines among them.

In short almost all of the important mines are included in the Inner Side of the Japan Arc, except a few deposits occurring in the provinces of Awa and Bungo.

## IRON SULPHIDE.

This ore was formerly used for the manufacture of red ocher and copperas, but the mining for this purpose is now restricted to only some few mines. At present pyrrhotite is used for this purpose, owing to the smaller percentage of sulphur in its contents. The utilization of iron pyrite for the manufacture of sulphuric acid is of comparatively late origin; and nowadays almost all sulphuric acid made in Japan comes from this source. The demand for iron pyrite is therefore gradually increased and the entire production is consumed in the domestic uses. The calcined ore has been utilized as a basic flux of copper smelting. The output of iron pyrite and pyrrhotite during 1908 amounted to 23,960 long tons valued at £13,635.

The outputs of the principal mines during 1907—1908 were as follows:—

| Mines. | Provinces. | Ores. | (long tons) 1908. | (long tons.) 1907. |
|---|---|---|---|---|
| Yanahara | Mimasaka | Iron pyrite | 10,200 | 19,115 |
| Hisagi | ,, | ,, | 3,558 | 6,737 |
| Iimori | Kii | ,, | 2,425 | 19,988 |
| Motoyama | Bitchū | Pyrrhotite | 1,973 | 1,950 |
| Kuchō | Iyo | Iron pyrite | 1,951 | 3,111 |
| Sankō | Wakasa | ,, | 1,562 | — |
| Iwagami | Ugo | ,, | 1,335 | 1,190 |
| Sano | Bizen | Pyrrhotite | 988 | 592 |
| Suwa | Hitachi | Iron pyrite | 754 | — |
| Shimo-Yanahara. | Mimasaka | ,, | 715 | 4,930 |
| Ōhidachinai | Ugo | ,, | 271 | 241 |

Ores:—Iron pyrite is the common ore for the manufacture of sulphuric acid. If the sulphur content falls below 40%, it is considered as valueless. The gossan or the oxidized ore of pyrite is sometimes treated as an iron ore as for example in the case of Yanahara in Bitchū. Pyrrhotite has less importance and also less occurrence than iron pyrite.

Deposits:—Pyrite is the most widely distributed mineral in nature, being found in many kinds of rocks and in all geological formations. It occurr in the forms of (1) Veins, (2) Metasomatic deposits, (3) Contact metamorphic deposits, and (4) Beds. The first and the third types are not so significant as in the case of the second and the fourth type. In the second type there is two kinds of deposits: (a) deposits in Tertiaries especially abundant in or near liparite intruded in them and (b) deposits in Pre-Tertiaries. In the fourth type a great number of deposits are included. They are imbedded in the crystalline schists, Palaeozoics and Mesozoics. The relations between the deposits and the geology of the principal mines are as follows:—

| Mines. | Provinces. | Deposits. | Geology. |
|---|---|---|---|
| Udo | Idzumo | Vein | Tertiaries & andesite. |
| Masukawa | Oshima | Metasomatic deposit. | Tertiaries. |
| Takara | Kai | ,, | Tertiaries & liparite. |
| Yanahara & its environs. | Mimasaka | ,, | Palaeozoics. |
| Motoyama | Bitchū | Contact-metamorphic deposit. | Palaeozoics & prophyrite. |
| Sano | Bizen | ,, | Palaeozoics & Granite. |
| Kune | Tōtōmi | Bed | Crystalline schists. |
| Iimori | Kii | ,, | ,, |
| Mochibe | Awa | ,, | ,, |
| Kuchō | Iyo | ,, | ,, |

Distributions:—The distribution of pyrite deposits is almost similar to that of copper. As in the case of copper, the pyrite deposits are well and equally distributed in Honshū, Shikoku and Kyūshū. Moreover there is a particular development for each type of deposits in the different regions in connection with the different geological formations.

# IRON.

The iron resources of Japan may be considered for the sake of convenience under the following four divisions: I. magnetite, II. hematite, III. brown iron ore or limonite, IV. iron sand.

I. Magnetite.—The iron ore of this kind is widely distributed and often occurs in considerable quantities. So far as is known, it occurs in the following 27 provinces:—Mutsu, Ugo, Rikuchū, Uzen, Iwaki, Hitachi, Shimotsuke, Echigo, Shinano, Kōtsuke, Kai, Musashi, Mino, Etchū, Echizen, Yamato, Harima, Mimasaka, Bitchū, Idzumo, Iwami, Aki, Nagato, Suō, Buzen, Hizen, and Satsuma.

In regard to the mode of occurrence, the magnetite ore makes its appearance in several classes of deposits, of which the most commonly prevailing and economically important is that of contact metamorphic deposit. As an example of this class of the deposit of the ore, we may give here a brief account of the Kamaishi mine in the Province of Rikuchū.

The Kamaishi mine, worked by C. Tanaka since 1888, is situated in the mountainous district known as Katabasan about 10 miles west of the harbour of Kamaishi, on the Pacific Sea-board in North Japan. There, a number of magnetite deposits occur as large irregular masses in the Paleozoic strata composed of limestone, clayslate and hornstone, within the contact areole of granite and diorite which have intruded them. The stratified rocks are all metamorphosed and the ore deposits are usually associated with the contact minerals, such as garnet, actinolite, augite, epidote, axinite, etc. Some ores carry a certain amount of iron and copper pyrites, which are more or less grouped at the peripherial portions of the ore masses. The majority of ore bodies is outcropped near the top, or on the steep slopes of the mountain attaining the height of over 1,500 feet above the nearest drainage level, so that the mining operation is easy. The ore mined is carried by means of inclines and wire-ropes down to the foot of the mountain and then conveyed by a tramway for a distance of about 10 miles to Sudzuko close to the harbour of Kamaishi, where it is charged in blast-furnaces. The annual output of the pig iron, ferromanganese, spiegeleisen, and open-hearth steel made in the iron works for the last three years is as follows:—

| | 1906 (long tons) | 1907 (long tons) | 1908 (long tons) |
|---|---|---|---|
| Pig iron | 28,713 | 30,213 | 34,289 |
| Ferromanganese | 906 | 1,077 | 770 |
| Spiegeleisen | 3,221 | 2,917 | 16 |
| Steel | 3,126 | 3,931 | 1,650 |
| Total | 35,966 | 38,138 | 36,725 |

Besides the above described mine, there are a vast number of contact metamorphic deposits of magnetite in several districts, among which those so far well known are the following:—

Hitokabe in Rikuchū; Awagadake or Kamo district in Echigo; Higashi-Kambara in Echigo; Kamichūka and the vicinity in Iwaki; Mikata in Harima; Dorogawa in Yamato; Ōigawa in Uzen; Ōhinata in Shinano; Nakakosaka in Kōtsuke; Yanagiga-ura in Buzen, etc.

The following analyses made by the Imperial Government Iron Works show the composition of some magnetite ores, mostly of the contact metamorphic deposits.

Analyses of some Magnetite Ores.

| District. | Iron. | Manganese. | Phosphorus. | Sulphur. | Copper. | Silica. | Insoluble residue. |
|---|---|---|---|---|---|---|---|
| Adzumadake (Mutsu) | 50.38 | 0.253 | 0.006 | 0.028 | None. | 14.60 | 17.36 |
| Rōgi (Rikuchū) | 60.99 | 0.253 | 0.002 | None. | Trace. | 5.30 | 5.94 |
| Kebaraichi (Rikuchū) | 65.02 | — | 0.013 | 0.061 | — | 4.06 | 4.21 |
| Kamaishi (Rikuchū) | 60.23 | — | 0.028 | 0.336 | 0.010 | 6.39 | 8.28 |
| Hitokabe (Rikuchū) | 55.69 | 0.380 | 0.460 | 0.580 | 0.400 | 14.10 | 17.62 |
| Kamichūka (Iwaki) | 64.02 | 0.145 | 0.007 | 0.015 | None. | 8.50 | 8.76 |
| Kamo (Echigo) | 69.63 | 0.185 | 0.014 | 0.005 | 0.038 | 2.10 | 2.49 |
| Higashi-Kambara (Echigo) | 60.86 | — | 0.031 | 0.112 | 0.090 | 6.14 | 6.48 |
| Nakakosaka (Kōtsuke) | 63.30 | — | 0.137 | 0.249 | 0.005 | 3.39 | 3.53 |
| Kahiru (Echizen) | 68.60 | 0.100 | 0.020 | None. | Trace. | 2.30 | — |
| Mikata (Harima) | 69.00 | 0.300 | 0.020 | None. | None. | 2.00 | — |
| Dorogawa (Yamato) | 63.00 | 0.100 | 0.020 | 4.900 | 0.210 | 2.80 | — |
| Yanagigaura (Buzen) | 68.66 | 0.120 | 0.063 | 0.031 | Trace. | 2.67 | 2.86 |

II. Hematite:—This kind of iron ore is known to occur in the following 21 provinces:—

Mutsu, Ugo, Rikuchū, Rikuzen, Iwashiro, Echigo, Mino, Kii, Tosa, Awa, Hōki, Harima, Mimasaka, Aki, Idzumo, Iwami, Nagato, Bungo, Buzen, Higo and Hyūga.

The hematite ore may be subdivided into two kinds (a) micaceous iron ore and (b) compact red iron ore.

(a) Micaceous Iron Ore :—This foliated iron ore occurs (1) as irregular masses of contact metamorphic origin and (2) in the form of veins.

In the majority of cases, this kind of hematite occurring in the contact metamorphic deposits is almost exclusively found in the Palaeozoic terrains which have suffered from intrusions of some igneous rocks, such as granite, porphyrite, liparite, etc. As to the examples of this type of the ore deposits, here may be mentioned the following two iron ore districts.

1. The Akadani iron ore district in Echigo :—The Akadani iron ore district is situated, about 32 miles east of the city of Niigata, along the river Iide, which takes a sinuous course in a westerly direction cutting the mountainous region bordering the eastern part of the plain of Echigo. The rocks developed there are limestone, slate, sandstone, hornstone and schalstein, and hornblende granite, liparite and andesite. The stratified rocks are known as of the Palaeozoic age. They are all metamorphosed by the intrusion of the garnite. The younger eruptive rocks, liparite and andesite, are found here and there in the forms of dykes through the Palaeozoic rocks and the granite. The micaceous iron ore locally known as "Girabaku" occurs in the form of irregular masses in the Palaeozoic rocks, particularly in limestone and slate, within the contact areole of the granite. The outcrops of ore masses number 50 or more, of which the largest one measures 420 feet in length and 200 feet in breadth. The ore is usually associated with the contact minerals, among which garnet and hedenbergite are prominent. Sometimes there occur, in the cavities of the ore, masses of minute rhombohedral crystals of siderite, probably of a secondary origin. A certain amount of iron and copper pyrites is occasionally found in the marginal parts of the ore deposits. This iron district will be exploited within a few years by the Imperial Government Iron Works.

2. The Sen-nin Iron Mine in the province of Rikuchū:—Within some 15 miles west of the Kurosawajiri Station on the Tokyo-

Aomori railway, there occurs number of micaceous iron deposits on both sides of the river Waga, which meanders in an easterly direction through the Sen-nin mountains from 800 feet to 1,000 feet high above the plain of Kurosawajiri.

The ore deposits are found mostly in the crystalline limestone and partly in the so-called gneiss coming in contact with the hornblende granite which has intruded through the stratified rocks.

The ore is associated with garnet, hedenbergite and some other contact minerals and sometimes carries a certain amount of iron pyrites. The latter is usually found as patches in the peripherial parts of the ore masses. The ore deposits on the south bank of the Waga have been worked since 1900 by Amenomiya, and the ore mined is smelted at Kiridome, about 1½ mile east of the mine. There are two blast furnaces, but one only having a capacity of 10 long tons is now in blast. The annual production of charcoal pig iron made there for the last three years was in long tons as stated below:

| | | |
|---|---|---|
| 1906 | 4,234 | 4,260 |
| 1907 | 3,071 | 3,070 |
| 1908 | 2,906 | 2,886 |

Aside from those above described, the micaceous iron ore of this type of occurrence is found in many other districts, among which Rikuchū and Echigo are well known.

The veins of micaceous iron ore are found in the rocks, either sedimentary or igneous, of the Palaeozic and still younger ages. The veins of this kind of ore in Tertiary rocks are found at Aone in Rikuzen, Sodeyama in Echigo, Ōkuzu in Ugo, etc. The ore is more soft and friable than that of the contact metamorphic deposits and is not unfrequently accompanied by copper and gold ores.

The following analyses made by the Imperial Japanese Govern ment Iron Works show the composition of some micaceous iron ores.

Analyses of some Micaceous Iron Ores of Japan.

| | Iron | Phosphorus. | Sulphur. | Silica. | Manganese. | Copper. | Insoluble residue. |
|---|---|---|---|---|---|---|---|
| Sen-nin (Rikuchū) | 61.55 | 0.005 | 0.118 | 11.59 | 0.052 | 0.040 | 11.91 |
| Omoye (Rikuchū) | 55.13 | 0.007 | 0.048 | 16.10 | 0.091 | 0.003 | 19.32 |
| Okuzu (Ugo) | 55.42 | 0.033 | 0.039 | 7.75 | 0.181 | None. | 7.98 |
| Aone (Rikuzen) | 55.60 | 0.010 | None. | 15.70 | 0.100 | Trace. | — |
| Narabara (Iwashiro) | 59.90 | 0.030 | 0.100 | 9.70 | 0.100 | Trace. | — |
| Akadani (Echigo) | 64.34 | 0.041 | 0.100 | 2.48 | — | 0.040 | 3.01 |
| Sodeyama (Echigo) | 60.72 | 0.047 | Trace. | 10.31 | 0.084 | None. | 11.26 |
| Itō (Idzumo) | 46.76 | 0.009 | 0.006 | 29.93 | 0.118 | 0.008 | 31.40 |

(b) Compact Red Iron Ore:—This sub-class of hematite is quite different both in the mode of its occurrence and in its chemical character from the above mentioned micaceous variety. It is usually compact and siliceous, though sometimes a high grade ore is found. The low grade ore is often blended with or passes into a ferruginous quartzite. It may be noted that the ore is comparatively high in contents of manganese and phosphorus, besides silica. It occurs in lenticular or platy form interstratified in crystalline schist, schalstein, radiolarian slate, quartzite, mostly of the Palaeozoic age. Sometimes it is found in Mesozoic rocks. The well known districts where this kind of hematite occurs in considerable quantities are in Tosa, Rikuchū and Higo, etc.

In Tosa, this compact hematite was mined during the last few years, and some thousand tons of the ore were shipped to the Imperial Government Iron Works in Chikuzen.

In Rikuchū, it occurs abundantly in the environs of the city of Morioka, particularly at Yanagawa and Isagozawa.

The chemical composition of this kind of hematite will be seen from the following analyses, made by the Imperial Government Iron Works:—

Analyses of some Red Iron Ores.

| | Iron. | Manganese. | Phosphorus. | Sulphur. | Silica. | Insoluble residue. | Copper. |
|---|---|---|---|---|---|---|---|
| Yonai (Rikuchū) | 35.71 | 6.48 | 0.14 | 0.060 | 38.21 | — | Trace |
| Asagishi (Rikuchū) | 62.62 | 1.00 | 0.056 | Trace | 36.43 | 36.64 | — |
| Isagozawa (Rikuchū) | 37.16 | 1.00 | 0.228 | Trace | 43.39 | 43.75 | 1 |
| Isagozawa (Rikuchū) | 66.35 | 0.141 | 0.017 | 0.053 | 1.67 | 2.14 | 0.002 |
| Yanagawa (Rikuchū) | 22.20 | 15.23 | 0.350 | 0.050 | 47.55 | — | None |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Aki (Tosa)** | 39.98 | 6.31 | 0.31 | 0.010 | 15.60 | — | None |
| **Ananai (Tosa)** | 43.44 | 6.91 | 0.17 | 0.005 | 19.60 | — | None |
| **Sōanji (Tosa)** | 53 22 | 5.38 | 0.281 | 0.075 | 9.38 | — | None |
| **Kōnotani (Tosa)** | 48.62 | 4.87 | 0.870 | 0.034 | 11.74 | — | None |
| **Oyashiki (Tosa)** | 39.10 | 3.90 | 0 778 | Trace | 2.01 | — | 0.04 |

III. Brown Iron Ore or Limonite:—Under the name of brown iron ore or limonite are included all the kinds of hydroxides of iron. According to their formation, they may be classified into (1) gossan ore and (2) bog and spring ore.

(1). Gossan ore is a name given to the limonite which has been formed under the oxidation of iron pyrites and some other iron sulphides: so, it is of a superficial occurrence. This kind of limonite is widely distributed and often occurs in ecomonic importance. The ore deposits now in actual mining operation are found in the Province of Buzen, Nagato and Mimasaka.

(2). Bog and Spring Ore:—The bog and spring ore is of very recent origin and in some localities it is now still under process of formation. The economically important deposits of this kind of ore are known in Hokkaidō, Ugo, Hizen, Ōsumi, and Satsuma.

In Hokkaidō, the well known deposits are met with at Abuta, west of the port of Mororan, and at Wakatasap, east of the Kutchan station on the Hakodate-Otaru railway and along the lower course of the Ishikari, a mighty river in Hokkaidō. At Abuta, the deposit measures 30 feet in thickness, though the extent is limited. The production of ore during 1906—1908 was reported as follows:—

| | long tons. |
|---|---|
| 1906 | 14,060 |
| 1907 | 15,346 |
| 1908 | 12,591 |

The ore produced has mostly been shipped to the Imperial Iron Works in Chikuzen.

In the province of Ugo, such an ore as that of Abuta, is widely distributed round the foot of the Chōkaisan, a well known volcano in North Japan. At Kotaki, near the coast of Kisagata, on the western foot of the volcano, the ore has at one time been worked and about some thousand tons have once been shipped to the Imperial Government Iron Works in Chikuzen.

The following analyses made by the Imperial Government Iron Works show the composition of some brown ores of the two classes of deposits above described:—

Analyses of some Brown Iron Ores.

| Localities. | Iron. | Manganese. | Silica. | Phosphorus. | Copper. | Sulphur. | Water. |
|---|---|---|---|---|---|---|---|
| **Abuta (Hokkoidō)** | 57 18 | 0.10 | 2.29 | 0.04 | None | 0.30 | 13.90 |
| **Wakatasap (Hokkaidō)** | 54.90 | 0.10 | 3.26 | 0.15 | None | 0.30 | 14.60 |
| **Kotaki (Ugo)** | 53 40 | 0.30 | 3.20 | 0.04 | 0.02 | 0.50 | 13.80 |
| **Naone (Ugo)** | 57.70 | 0.05 | 1.55 | 1.08 | Trace | 0.74 | 14.21 |
| **Tarō (Rikuchū)** | 51.47 | None | 2.32 | 0.05 | Trace | 0.60 | — |
| **Yanahara (Mimasaka)** | 56.60 | Trace | 5.50 | 0.05 | 0.05 | 0.40 | 10.00 |
| **Takata (Aki)** | 55 60 | 0.20 | 5.50 | 0.11 | 0.07 | 0.10 | 12.30 |
| **Ofuku (Nagato)** | 62.10 | Trace | 1.10 | 0.08 | 0.07 | 0.10 | 9.20 |
| **Hirao (Buzen)** | 58.50 | 0.20 | 3.20 | 0.04 | 0.05 | Trace | 10.50 |
| **Kawatana (Hizen)** | 57.30 | 0.10 | 5.30 | 0.14 | None | Trace | 12.40 |
| **Masaki (Hyūga)** | 53.10 | 0.50 | 7.70 | 0.05 | None | 1.00 | 11.00 |
| **Makisono (Ōsumi)** | 54.12 | Trace | 3.50 | 0.15 | None | 0.786 | — |
| **Makurasaki (Satsuma)** | 40.50 | 0 10 | 3 28 | 0.07 | 0.21 | 0.30 | 5.60 |

IV. Iron Sand.—In Japan the iron sand industry has been known from remote antiquity. The only material from which Japanese swords and other articles of cutlery were made was nothing but the steel manufactured from this class of ore.

Among the district where the iron sand occurs in commercial quantities, the following provinces are well known since long ago as the most important:—

| Province | Prefecture. | |
|---|---|---|
| **Idzumo, Iwami** | **Shimane.** | **South Japan.** |
| **Hōki** | **Tottori.** | **South Japan.** |
| **Aki, Bingo** | **Hiroshima.** | **South Japan.** |
| **Bitchū, Mimasaka** | **Okayama.** | **South Japan.** |
| **Rikuchū** | **Iwate.** | **North Japan.** |
| **Ugo** | **Akita.** | **North Japan.** |
| **Mutsu** | **Aomori.** | **North Japan.** |
| **Hokkaidō** | — | **North Japan.** |

(a.) Iron sand in South Japan:—The iron sand districts in South Japan occupy a large tract of the region known as Chūgoku and consist, for the most part, of granite, diorite, and some volcanic rocks, all of which under disintegration gave rise to the magnetic iron sand deposits. The iron sand is usually classified into the two varieties of (a) "Masa" and (b) "Akome." The "Masa" is light-coloured and contains many quartz grains and is less easily fusible than Akome. It is chiefly used for steel manufacture. The coarse grained variety is known as "Aramasa." "Akome" is usually of a reddish colour caused by the presence of hydroxide of iron, being easily fusible and mostly used for the manufacture of pig iron. A certain kind of "Akome" is called "Momiji," on account of the presence of hematite with which it is mingled.

In these districts, the iron sand is washed and smelted by the natives during 6 months in every year from the end of September to the end of March in the next year. The iron produced there is usually classified into the varieties of 1. pig iron, 2. "Kera," 3. steel and 4. wrought iron. An analysis of "Kera" was made by the Geological Survey of Japan with the following results: carbon 3.94; iron 95.18; phosphorus 0.35; manganese 0.05; silicon 0.11.

The production of iron in the Chūgoku for 1907 was reported as follows, in long tons:—

| Prefectures. | Pig iron | Kera. | Wrought iron. | Steel. |
|---|---|---|---|---|
| Tottori | 1,411 | 319 | 437 | 289 |
| Shimane | 1,283 | 524 | 148 | 1,217 |
| Hiroshima | 1,939 | 29 | 492 | — |
| Okayama | 68 | — | — | — |
| Total | 4,701 | 871 | 1,078 | 1,501 |

(b). Iron sand in North Japan.—The most productive iron sand districts are known to be the following:—

In Rikuchū the iron sand is found abundantly in the mountainous or hilly districts in the environs of Kuji. There it is often associated with auriferous sand.

In Mutsu it occurs in large quantities on the coast of Ōhata on the northern extremity of the province, and also in the environs of Ajigasawa on the north-western coast of the Province.

In Hokkaidō magnetic iron sand is found in large quantities, along the coast of Volcano Bay on the southern part of the island. There the total output of iron sand for 1908 was reported as 1,004 long tons. The source of the iron sand is known to be andesite or basalt. The similar iron sand is also found on the coast of Shirikishinai, on the south side of the Esan Promontory, east of Hakodate.

## CHROMIC IRON.

The discovery of chromic iron ore is of a comparatively late occurrence. Its mining was operated in several districts, but many of the deposits so far as found up to-day have already become exhausted, owing to their small masses and the facility in mining them on account of the favourable nature of the adjoining rock. The following is the complete list of the output during 1907—1908:

| Mines | Provinces. | 1908. (long tons.) | 1907. (long tons) |
|---|---|---|---|
| Wakamatsu | Hōki | 2,004 | 1,475 |
| Niimi | Bitchū | 200 | 768 |
| Takase | " | 220 | — |
| Sasaguri | Chikuzen | — | 47 |
| Mudagao | " | 20 | — |

All these productions have been expected.

Ores:—The ore sometimes occurs as (1) detrital deposits, but more commonly is found in serpentine as (2) an eruptive deposits. It is scattered through the serpentine derived from gabbro or peridotite in irregular masses which are often of considerable size. The ore occurs in a number of localities, but now it is being worked only in the Wakamatsu mine at Hōki where the ore will continue to furnish most of the product. The ore is very easily mined and is said to average of 40% of $Cr_2O_3$. On the upper course of the Mukawa at the province of Iburi in Hokkaidō, chromite occurs in an extensive area of serpentine both in the forms of masses and gravels.

Distributions:—Serpentine is undoubtedly the country rock of chromite which occurs widely in the regions of older geological formations. The ores are found in abundance near the boundary between the provinces of Hōki and Bitchū, especially in Atetsu county in Bitchū.

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## MANGANESE.

Distribution and Production:—In this country manganese ore is one of the most widely distributed of all the mineral resources. So far as is known it occurs in 47 of the 68 provinces of the Main Land (Honshū), Shikoku and Kyūshū, and in 2 of the 11 provinces of Hokkaidō.

The following table gives the provinces where manganese ore is known to exist, together with the actual production from provinces where mines are in active working order in the years 1907—1908, inclusive:—

| Provinces. | Production. (long tons.) | (long tons.) |
|---|---|---|
| Hokkaidō, | | |
| Shiribeshi | 8,741 | 3,400 |
| Oshima | — | — |
| Main Land (Honshū), | | |
| Mutsu | 2,259 | 3,322 |
| Rikuchū | 322 | 258 |
| Ugo | — | — |
| Rikuzen | — | — |
| Iwashiro | — | — |
| Echigo | — | 7 |
| Shinano | 41 | 11 |
| Shimotsuke | 444 | 341 |
| Kōtsuke | 57 | 14 |
| Hitachi | 26 | 55 |
| Musashi | 16 | — |
| Sagami | — | — |

| | | |
|---|---|---|
| Tōtōmi | — | — |
| Idzu | 22 | 25 |
| Mikawa | 15 | — |
| Mino | 440 | 92 |
| Ise | — | — |
| Shima | — | — |
| Noto | 304 | 246 |
| Echizen | — | — |
| Wakasa | — | 3 |
| Ōmi | 104 | 10 |
| Yamashiro | 260 | 58 |
| Yamato | — | — |
| Tango | — | — |
| Tamba | 3,237 | 1,709 |
| Settsu | — | — |
| Harima | — | — |
| Inaba | — | 22 |
| Hōki | — | — |
| Iwami | 494 | — |
| Mimasaka | — | 6 |
| Bizen | — | — |
| Bitchū | — | — |
| Suwō | 130 | — |
| Nagato | 54 | — |
| Shikoku, | | |
| Awa | — | — |
| Tosa | 764 | 974 |
| Iyo | 926 | 120 |
| Kyūshū, | | |
| Chikuzen | — | — |
| Chikugo | — | — |
| Buzen | — | — |
| Bungo | 1,671 | 249 |
| Hizen | — | — |
| Higo | — | 41 |
| Hyūga | — | 37 |
| Ōsumi | — | — |
| Total | 20,337 | 11,000 |

It may be noted that besides those now worked there are a large number of deposits which may be exploited when transportation facilities are provided.

Occurrence:—Mineralogically considered, it is most probable that the manganese ore of economic importance is a certain mixture of two or more kinds of the oxides such as psilomelane, pyrolusite, wad, etc. In a few cases manganite occurs in slender prismatic crystals having a black colour and a submetallic lustre in cavities of the other manganese deposits such as those in Mutsu and Echigo. Not unfrequently psilomelane is found in compact radiofibrous aggregates or botryoidal masses, such as those known in the deposits in Ugo and Noto.

From a geological point of view, the manganese ore falls into two main distinctive groups, namely: (a) the ore in rocks of the Palaeozoic (or partly Mesozoic?) and still older ages and (b) the ore in the Tertiary and still later formations.

(a). Manganese ore in older formations.

This group of manganese ore is geographically more widely distributed than those in the younger rocks, occurring in 44 out of 49 of the provinces stated in the table already referred to.

The rocks known as the repositories of the ore are gneiss, sericite schist, quartzite or hornstone, radiolarian slate, schalstein and clay-slate, the most of them belonging to the Palaeozoic age.

In the majority of cases, the deposits are lenticular or irregular in form, lying nearly parallel to the bedding of the rock in which they occur. Sometimes they are met with in cracks or fissures through which the rock is charged. As to their sizes, they vary within wide limits, from a small lump up to a big mass out of which a hundred or more tons of clean ore could be gained.

As a rule, the ore repositories are found exclusively in the zone of oxidation or "Katamorphic zone," that is to say, of rock in the process of weathering and so they are easily mined by open cuts or shallow pits. When working underground, we often come across the ore in which rhodonite appears. Consequently we are inclined to believe that this kind of ore was derived under conditions resulting from the alteration of rhodonite and some other manganese silicates.

By far the most widely distributed and economically important ore is for the most part found in quartzite, hornstone, radiolarian slate or schalstein. Almost all the deposits now worked in Pre-Tertiary regions belong to this variety of ore. As is well known, at Toba, in Shima, this kind of ore is occasionally associated with a light-yellowish phosphoric mineral which often contains fragments of manganese ore reminding us that its formation is later than that of the former.

(b.) Manganese ore in Tertiary and later formations, so far as is known occurs in economic quantities in Noto, Ugo, Mutsu and Hokkaidō.

At Searashi, in Noto, it occurs in irregular nodular masses, from the size of small pebbles to those weighing many tons, in greenish coloured tuff-breccia, which is for the most part altered into clay. The ore masses are often associated with jasper which probably has been formed by the partial replacement of the rock by silica.

On the coast of Koiji in Sudzumizaki, Noto, there occur sporadically some masses of ore within the area probably underlain by basalt.

At Fuku-ura, Mutsu, a manganese ore bed, from 2 to 4 feet thick, is interstratified in a Tertiary shale which manifests a gentle undulation. Beneath the ore bed are found a number of nodular ores lying nearly parallel to the bedding of the enclosing rock. The ore bearing portions of the rock are altered into a clay or so-called "Shabontsuchi" (soap clay), while the nodular ore is popularly known as "Shabonkui" (soap eater). As observed in Noto, the ore is associated with jasper which is well known by the local name of "Toraishi" (tiger-stone). The toraishi is often coated with manganese oxides.

At Ōwani, on the southern part of Mutsu, there is found a manganese vein about 3 feet wide in a fissure in liparite which is altered on either side of the vein into a clayey mass, the so-called soapstone.

In Hokkaidō, there are active mines in the provinces of Shiribeshi and Oshima, on the western part of the Island. The Pirika mine in Shiribeshi is situated about 8 miles north-west of Kunnui Station on the Hakodate-Otaru railway. The ore occurs in irregular nodular masses, measuring from 1 to 3 feet in thickness in a Tertiary bed made up of sandstone, shale and breccia, all tufaceous, striking N 70° E with a NW dip at an angle of about 25°. The ore-bearing bed is underlain by a coarse granular hornblende granite and covered by a gravel bed presumably of the Diluvial epoch. In the gravel bed is also found manganese ore as irregular nodules, and sometimes coating the pebbles of granite and andesite. In is also known that the ore is met with at roots of trees which grow there on the surface of the gravel beds. Such a mode of occurrence as the above holds good also with ores now quarried in the neighbouring districts.

Chemical nature:—The following analyses made by the Imperial Government Steel Works show the composition of some manganese ores mined in several provinces.

Analyses of some Manganese Ores.

| | Manganese. | Iron. | Silica. | Sulphur. | Phosphorus. | Copper. | Water. |
|---|---|---|---|---|---|---|---|
| **Hokkaido,** | | | | | | | |
| Oshima | 53.0 | 3.0 | 6.9 | Trace | 0.11 | Trace | 7.9 |
| **Main Land,** | | | | | | | |
| Mutsu | 50.7 | 3.5 | 8.5 | None | 0.69 | „ | 2.8 |
| Rikuchū | 46.9 | 2.4 | 21.2 | Trace | 0.02 | None | 21.1 |
| Mino | 54.7 | 1.2 | 1.5 | None | 0.40 | 0.01 | 3.6 |
| Ise | 52.5 | 1.6 | 4.3 | „ | 0.21 | Trace | 6.8 |
| Noto | 48.2 | 3.7 | 4.1 | „ | 0.11 | „ | 5.8 |
| Mikawa | 49.5 | 3.0 | 4.6 | „ | 0.19 | 0.01 | 4.1 |
| Shima | 50.7 | 3.4 | 2.5 | Trace | 0.14 | 0.10 | 6.0 |
| „ | 49.9 | 4.0 | 3.8 | „ | 0.29 | 0.19 | 5.0 |
| Ōmi | 47.2 | 2.0 | 8.1 | None | 0.16 | 6.42 | 5.2 |
| Tamba | 51.8 | 1.9 | 3.9 | „ | 0.15 | Trace | 6.1 |
| „ | 56.7 | 1.7 | 0.8 | „ | 0.09 | 0.05 | 4.2 |
| Iwami | 47.3 | 1.0 | 14.8 | „ | 0.30 | Trace | 5.1 |
| Suwō | 54.6 | 2.5 | 2.5 | Trace | 0.10 | 0.03 | 3.0 |
| **Shikoku,** | | | | | | | |
| Iyo | 55.0 | 1.6 | 2.1 | None | 0.19 | 0.07 | 5.1 |
| „ | 49.2 | 2.5 | 9.1 | „ | 0.11 | Trace | 5.8 |
| Tosa | 51.9 | 1.8 | 3.0 | Trace | 0.08 | „ | 5.9 |
| „ | 44.9 | 5.2 | 7.7 | None | 0.15 | 0.02 | 10.4 |
| „ | 55.8 | 1.4 | 2.4 | „ | — | Trace | 3.2 |

# TIN.

The production of tin has decreased gradually since the year 1891, but recently a few mines have re-opened their works on account of the rise of the price of the metal and consequently there was a little increase in the production. The yearly output has fluctuated between 30,000—100,000 lbs. for 18 years and in the year 1908 it amounted to 46,410 lbs. valued at £2,855. The output is an insignificant proportion of the total domestic consumption and the greater part of the tin is imported annually from the Straits Settlements. During 1908 the imports amounted to 1,680,032 lbs. valued at £98,271. The output of each mine during 1907—1908 was as follows:—

| Mines. | Provinces. | 1908. (in pounds.) | 1907. (in pounds.) |
|---|---|---|---|
| Taniyama | Satsuma | 41,920 | 38,153 |
| Nagao | Ōsumi | 408 | 1,767 |
| Iwato | Hyūga | 364 | 2,177 |
| Mitate | " | 141 | — |
| Kiura | Bungo | — | 637 |
| Taniyama (Detrital deposits) | Satsuma | 4,279 | 9,844 |
| Nayegi " | Mino | 2,500 | 2,275 |
| Sudzukōya " | Hitachi | 350 | 191 |

Ores:—The common ore is cassiterite. It is always associated with several sulphides such as pyrite, pyrrhotite, zincblende, chalcopyrite, arsenopyrite, etc., and is often accompanied with wolframite or scheelite.

Deposits:—Their modes of occurrence are (1) veins, (2) metasomatic deposits, (3) contact-metamorphic deposits and (4) detrital deposits. Among them the first and the last are the important producers of tin in Japan. The most parts of the veins are found in the strata of the Palaeozoics and the Mesozoics or sometimes in granite. According to the statistics the outputs derived from alluvial working is less than 20% of that of the total output of tin.

The following is a list of the important mines:—

| Mines. | Provinces. | Deposits | Geology. |
|---|---|---|---|
| Taniyama | Satsuma | Vein | Mesozoics. |
| Iwato and Mitate | Hyūga | " | Palaeozoics. |
| Akenobe | Tajima | " | " |

| | | | |
|---|---|---|---|
| Nagao | Ōsumi | Veins. | Granite. |
| Ushine | ,, | Metasomatic deposit. ? | Mesozoics. |
| Kiura and it environs. | | Contact-metamorphic deposit. | Polaeozoics near quartz-porphyry. |
| Taniyama | Satsuma | Detrital deposit. | Derived from the veins in Mesozoics. |
| Nayegi | Mino | ,, | Derived from pegmatite veins in granite. |
| Sudzukōya | Hitachi | ,, | Derived from the veins in Palaeozoics. |

Distributions:—The deposits are found in restricted areas such as in the provinces of Satsuma, Ōsumi, Hyūga and Bungo in Kyūshū. The Taniyama mine in Satsuma is the largest producer of tin in Japan. It is said that this output is wholly used for making tin utensils celebrated in that district. The boundary between the provinces of Hyūga and Bungo is the extensive area for tin deposits. They are bedded veins between the limestone and the quartzite of the Palaeozoic formation on the one side and contact-metamorphic deposits between the limestone and the quartz-porphyry on the other. They are composed chiefly of pyrrhotite sometimes of arsenopyrite, chalcopyrite or zincblende while cassiterite are found in quartz veinlets traversed among them. A narrow but very rich ore was discovered quite recently in the Akenobe mine in Tajima. It is a quartz vein traversing parallel with the argentiferous copper vein and is associated with wolframite. In the Nayegi district in Mino a cassiterite bed is found in the diluvium strata directly on the granite bed-rock, where the ore is associated with several rare minerals such as smoky quartz, topaz, saphire, fergusonite, nayegite, wolframite, etc.

## ANTIMONY.

The working of antimony began from the year 1876, and in a few years it grew suddenly, the yearly production fluctuating from £10,000 to £40,000. In 1908 it amounted to 138 long tons of refined antimony valued at £4,489 and 73 long tons of crude metal valued at £1,307. In recent years much crude antimony was imported from China annually, and after being refined, was again shipped to Hong-kong, China and Germany. In 1908 the exports amounted to 205 long tons valued at £5,997. The quantities of the imports and the exports were nearly balanced annually and the domestic production was sufficient to supply the domestic demand. Lately the scarcity of good ores and the fall of the price plunged the mines into great difficulty and only a few of them are working now.

The outputs of the important mines during 1907—1908 were as follows :—

| Mine. | Provinces. | 1908. (in long tons.) | 1907. (in long tons.) |
|---|---|---|---|
| Ichinokawa | Iyo | 118 (refined)<br>2 (crude) | 77 (refined) |
| Kano | Suwo | 259 (ore) | 372 (ore) |
| Tengu-iwa | Hyūga | 35 (crude) | 77 (crude) |
| Hanta | Yamato | 23 (crude) | 36 (crude) |

Ores :—Stibnite is the most important ore of antimony. It is usually associated with a greater or less amount of quartz gangue and occasionally carries gold.

Deposits :—These occur most generally in veins intersecting Mesozoic strata, frequently in Palaeozoic but very rarely in crystalline schists or Tertiaries. They are also often found in sedimentary rocks near their junctions with intrusive quartz-porphyry or within the eruptive rock itself. In Japan, the Mesozoic strata are rather characterized for the scarcity of mineral resources. But this is the exceptional cases for antimony only.

The following is a list of the chief localities :—

| Mines. | Provinces. | Deposits. | Geology. |
|---|---|---|---|
| Kano | Suwō | Vein | Mesozoics |

| | | | |
|---|---|---|---|
| Hanta | Yamato | Vein | Mesozoics |
| Taguchihara | Hyūga | ,, | ,, |
| | | | and Mesozoics. |
| Ichinokawa | Iyo | ,, | Crystalline schists |
| Nakase | Tajima | ,, | Palaeozoics. |
| Nakagawa | ,, | ,, | ,, |
| Arahira | Hyūga | ,, | ,, |
| Amatsutsumi | ,, | ,, | Quartz-porphry |

Distribution.—Along the Mesozoic strata which extends from the province of Yamato through Tosa and Iyo in Shikoku to Hyūga and Ōsumi in Kyūshū, a great number of mines have been districted. A few other small mines are also located independently in Tajima, Suwō and Nagato. Generally speaking these distributions are entirely included in the South Japan Arc and especially plentiful in the Outer Side.

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## MERCURY.

The ore has not hitherto been profitably worked, although deposits have for some years been known to occur in several districts. The Suigin mine at Suii in Awa, Shikoku, is the only one mine which is now operated. The total output duriug 1908 amounted to 1,541 lbs. valued at £144. But it is an insignificant proportion of the total domestic consumption and hence a large quantity of mercury is imported annually from Spain, England and the United States. In 1908 the imports amounted to 153,600 lbs. valued at £16,141.

Ores:—Mercury is often found in the native state but the most common ore is cinnabar.

Deposits:—There are two kinds of deposits, i.e. (1) veins and impregnation, and (2) detrital deposits. The latter has little or no importance for the production, while the former, three types may be recognizable: (a) cinnabar sublimated or crusted in rock fissures and also impregnated into the soft parts; (b) cinnabar in quartz veins in which gold has been associated; (c) minutes globules of native mercury are disseminated or arranged in vein-like forms in Tertiary sandstone.

The following is a list of the chief localities in Japan:—

| Mines. | Provinces. | Deposits. | Geology. |
|---|---|---|---|
| Suigin. | Awa. | Vein and impregnation (a) type. | Mesozoics. |
| Chichinokawa. | Iyo. | ,, | ,, |
| Hirukodate. | Rikuchū. | ,, | Paleozoics. |
| Hasami. | Hizen. | Vein and impregnation (b) type. | Tertiaries near liparite. |
| Okuchi & Ushio. | Satsuma. | ,, | Andesite. |
| Yamaguchi-mura. | Hizen. | Vein and impregnation (c) type. | Tertiaries. |
| Minato-mura. | Hyūga. | ,, | Tertiaries. |
| Rivers Uryu and Sorachi. | Hokkaidō. | Detrital deposits. | Alluvium. |

Distribution:—The principal localities are in Shikoku. The rest of them are situated in the zone ef the Outer Side of Japan Arc. At the Suigin mine in Awa cinnabar is found along the plane of fault in the Mesozoic limestone. The deposit is in minute veinlets and impregnatoins, cinnabar sometimes beíng associated with calcite crystals perhaps of the secondary origin.

## TUNGSTEN.

The ores though occurring in a number of localities, have not hitherto been found in any extensive deposits. Formerly the Kurasawa mine in Kai has been worked for this ore to some extent, but subsequently workings were abandoned owing to the decrease of the ores. Nowadays no mine has produced the ore in quantities available for commercial purposes.

Ores:—The principal ores found in Japan are scheelite and wolframite. They are commonly associated with cassiterite, bismuth ore or molybdenite with the characteristic gangues which contain fluorin or boron such as fluorite, topaz, tourmaline, apatite and axinite.

Deposits:—The deposits occur for the most part with reference to granitic or liparitic rocks. There are three types of deposits (1) as veins, (2) as contact-metamorphic deposits and (3) as detrital deposits, of which the last type has no economical importance.

The following is a list of the principal localities with the relations between their deposits and geology:

| Mines. | Provinces. | Deposits. | Geology. |
|---|---|---|---|
| Nishizawa | Simotsuke | Vein. | Liparite. |
| Kurasawa | Kai | ,, | Granite. |
| Akenobe | Tajima | ,, | Palaeozoics. |
| Kanoya | Ōsumi | ,, | Mesozoics. |
| Naganobori | Nagato | Contact-metamorphic deposit. | Palaeozoic limeston and granite. |
| Otogafuchi | Hyūga | ,, | Palaeozoics near quartz-porphyry. |
| Nayegi | Mino | Detrital deposit. | Diluvium strata derived from the granite. |

Distribution:—Tungsten has many scattered occurrences. As already stated in the above list, at Nishizawa wolframite and hübnerite occur in auriferous quartz veins but unfortunately many minute crystals of iron pyrites are frequently atttached to their faces. At the Kurasawa mine scheelite and ferberite occur in the pegamatitic quartz veins in granite. It has been once actively operated for getting them, but now it has become merely a mine of rock-crystal. The occurrence of the ore in the Kanoya mine is nearly similar to that in the Kurasawa mine with the difference of the presence of wolframite instead of ferberite. At Akenobe large wolframite plates are associated with cassiterite in quartz veins. The occurrences of the metal in the mines of Naganobori and Otogafuchi are somewhat similar and they both have been associated with copper ore. Besides the above mines there are several other localities that are known to be productive in the province of Satsuma, Buzen in Kyūshū, and Nagato, Suwō and Hitachi in Honshū.

# BISMUTH.

This metal had been once extracted from the ores of Nishizawa (gold silver mine) in Shimotsuke and Kamioka (silver lead mine) in Hida. Even now about 0.2% of bismuth is contained in the lead derived from the Kamioka mine. Quite recently the Kosaka (silver copper mine) in Rikuchū and Imo-oka in Mimasaka has produced a small amount of the metal and the ore respectively, thus:—

| | |
|---|---|
| From Kosaka | 793 lbs. of the metal (95.2% Bi) Valued at £345. |
| From Imo-oka | 1,041 lbs. of dressed ore (25% Bi) |

The ore is known to occur in many other places but it has not yet been found in large quantities.

Ores:—The principal ores of this metal are native bismuth and bismuthinite. They are frequently associated with those of tungsten and molybdenum and sometimes with gold and silver or copper.

Deposits:—The ore occurs in two forms as (1) veins and (2) contact-metamorphic deposits. In the former type it is frequently associated with gold, silver or copper ores and occurs in granitic or liparitic rocks, while in the latter type it occurs more commonly with the ores of tungsten and molybdenum in the rocks of the older geological formations.

The following is the list of the principal localities:—

| Mines | Provinces | Deposits. | Geology. |
|---|---|---|---|
| Nishizawa | Shimotsuke | Vein | Liparite |
| Nakanosawa | Yechigo | ,, | ,, |
| Kanagase, Ikuno | Tajima | ,, | ,, |
| Imo-oka | Mimasaka | ,, | Granite |
| Hade | ,, | ,, | ,, |
| Tomikuni | Tamba | ,, | ,, |
| Kamioka | Hida | Contact-metamorphic deposit. | Gneiss, limestone near quartz-porphyry. |

Distribution:—There are many scattered occurrences throughout the Inner Side of both the North and South Japan Arc. At Nishizawa bismuthinite is found only in the bonanza intermixed with argentite, but at Nakanosawa it forms separate veins traversing and running parallel with the gold veins. At the mine of Tomikuni, Imo-oka and Hade it has associated with chalcopyrite and some quantities of bismuth one may be obtainable. At Kanagase in the Ikuno mine native bismuth with small quantities of bismuthinite occurs in copper ore but is not abundant. At Kamioka no bismuth ore can be found with the naked eye, but a tolerable quantity of this metal is to be found in lead by chemical analysis. At Kosaka metallic bismuth is extracted from the litharge resulting from the cupellation. There are several other localities known to produce this ore in the provinces of Nagato and Bungo but they are now only the localities for mineral specimens.

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## MOLYBDNEUM.

Hitherto many localities are known to produce this ore but only a few of them have been prospected and the rest are not yet opened. Hence up to the present time no mine has produced the ore in commercial quantities.

Ores:—Molybdenite is the chief source of this metal.

Deposits:—The occurcence of molybdenite is similar to that of bismuth, i.e. (1) veins and (2) contact-metamorphic deposits. The latter is not so important as is the former for the production of ores. It frequently has been found associated with the ores of bismuth or tungsten but it commonly occurs alone in quartz veins and pegmatite. The most part of geology is directly or indirectly confined to granitic rocks. Quartz is the common carrier of molybdenite which is commonly vein quartz but often pegmatitic. Those two kinds of quartz are so much alike that it is difficult to distinguish between them at a glance. The chief localities are as follows:—

| Mines. | Provinces. | Deposits. | Geology. |
|---|---|---|---|
| Shirakawa | Hida | Vein | Gneiss. |
| Ida | Bizen | ,, | Granite. |
| Yamasa | Idzumo | ,, | ,, |
| Iishi | ,, | ,, | ,, |
| Kawauchiand its environs | Yechigo | Contact-metamorphic deposit. | Palaeozoics near granite. |

Distribution :—The most parts of the localities are distributed in the granitic regions which stretch along the Inner Side of the South Japan Arc. A few others are also situated in the continuation of this granite which borders the above limit. At Yamasa in Idzumo massive and scaly molybdenites are found in quartz vein and partly impregnated in the country rock which has become of clayey nature by its decomposition. At Shirakawa in Hida molybdenite masses occur in clayey veins and sometimes a few tons of high grade ore can be obtained even in a mass. At Kawauchi in Yechigo molybdenite occurs with quartz in granite and in the same district other kinds of deposits are found associated with the so-called contact minerals of garnet and pyroxene. There are several other localities known to produce this ore in the provinces of Buzen, Hyūga, Bungo in Kyūshū; Aki, Idzumo, Mimasaka, Bizen, Inaba, Kai, Yetchū and Hida in Honshū; but they are now considered as only the localities for mineral specimens.

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## ARSENIC.

The arsenic-bearing minerals are widely distributed in many mines, but little attention has been attracted to utilize them until recently. Arsenic sulphide was manufactured as a pigment in the Kawauchi mine in Echigo, and arsenious oxide was made quite recently in the mines of Uridani and Otogafuchi in Bungo and Hyūga respectively. In 1908 the production of arsenious oxide amounted to

27,550 lbs. valued at £169 and that of arsenious sulphide amounted to 17,200 lbs. valued at £101. The demand for arsenious oxide for medicine and other uses has increased considerably, and some quantities of it were imported.

The following is the complete list of the production during 1907—1908:

| Mines. | Provinces. | | 1908. Pounds. | 1908. Value. | 1907. Pounds. | 1907. Value. |
|---|---|---|---|---|---|---|
| Otogafuchi | Hyūga | Arsenious oxide | 24,750 | £152 | — | — |
| Uridani | Bungo | " | 2,800 | 17 | — | — |
| Kawauchi | Echigo | Arsenious sulphide | 15,000 | 79 | 14,246 | £74 |
| Hideya-mura | " | " | 2,200 | 12 | 2,666 | 14 |
| Ōgiri | Bungo | Ore | 83,333 | 12 | — | — |
| Kinaoshi | Hokkaidō | " | 33,333 | — | — | — |

Ores:—Arsenopyrite is the only ore mined at present. It is sometimes auriferous and has been treated as gold ore.

Deposits:—Arsenopyrite is one of the most widely distributed minerals. It occurs (1) as veins, (2) as metasomatic deposits and (3) as contact metamorphic deposits, while realgar and orpiment are rather rarely found (1) as veins and (2) as effused masses associated with sulphur. As veins arsenopyrite is well developed both in the Tertiary and Pre-Tertiary rocks, but in the other two types it is confined to Pre-Tertiary rocks. Realgar and orpiment occur mostly in Post-Tertiary rocks and are especially abundant in volcanics. The relations between deposits and geology of the several mines are as follows:—

| Mines. | Provinces. | Deposits. | Geology. |
|---|---|---|---|
| Otogafuchi | Hyūga | Contact-metamorphic deposit | Palaeozoics near quartz-porphyry |
| Kawauchi | Echigo | " | Palaeozoics near granite.? |
| Uridani | Bungo | Vein and partly metasomatic deposit. | Palaeozoics. |
| Ōgiri | " | Vein | " |
| Sudzukura | Kai | " | Granite. |

Distribution:—The mines which are now operated for these minerals are very few. The boundary region between the provinces of Hyūga and Bungo is one of the chief localities. Otogafuchi, Uridani and Ōgiri mines are working there for the manufacture of arsenious oxide. At Sudzukura in Kai, veins of arsenopyrite charged with rich gold occur in granite. The Kawauchi in Echigo is the first mine that commenced the manufacture of arsenious sulphide. There is one more mine at Hideyamura in the same province. In Hokkaidō two mines at Jōzankei and Kinaoshi were worked for realgar, but they had been already abandoned. Recently the latter mine has been re-opened.

## SULPHUR.

The production of sulphur has steadily increased with only a little fluctuation since the Restoration. In 1908 the production amounted to 33,785 long tons valued at £81,145 which occupies the seventh rank among the mineral productions in Japan. Though this production of sulphur is exceedingly inferior when compared with that of Italy and the United States, yet it takes the third rank in the list of sulphur productions throughout the whole world and indeed it was the second until the year 1902 when the rapid progress of the United States overcame it. As the domestic demand is very small, almost the entire production was shipped to the United States, Australia, Hawaii, China, Canada, etc.

The following are the principal mines which have produced sulphur during 1907—1908:—

| Mines | Provinces. | 1908. (in long tons) | 1907. (in long tons.) |
|---|---|---|---|
| Oshino | Hokkaidō | 9,458 | 10,034 |
| Kobui | ,, | 5,575 | 5,569 |
| Numajiri | Iwashiro | 5,284 | 1,544 |
| Iwaonupuri | Hokkaidō | 3,002 | 1,578 |
| Kumadomari | ,, | 2,007 | 3,176 |
| Shikabe | ,, | 1,791 | 1,817 |
| Kujusan | Bungo | 1,332 | 2,043 |
| Hokuto | Formosa | 810 | 572 |
| Sulphur Island | Satsuma | 609 | 609 |
| Uguisuzawa | Rikuchū | 592 | 791 |
| Tsurugizan | ,, | 17 | 1,765 |

In Japan only high-grade ores are treated and those below 40% sulphur are seldom worked.

Deposits:—The occurrence of native sulphur in Japan is of the "Solfatara type" in volcanic regions. By the mode of deposition several types may be recognizable in it, i.e.

(1.) Incrustation, impregation and replacement of sulphur from sulphurous gases on the rocks of the solfatara.

(2.) Flowing streams of sulphur, the flowing of mud mixed with sulphur, and sulphur blocks ejected during the eruption of a volcano.

(3.) Beds of sulphur deposited in lakes in situ or precipitated in other parts; thus forming the remnant of the old crater lake, etc., or a stratum of Tertiary or Dilvium rocks.

(4.) Sulphur precipitated chemically from a hot spring such as sinter deposits.

The deposits of the first three types furnish nearly the entire bulk of the sulphur of commerce. The output from the last type is in considerably smaller quantities in comparison with the rest and has been used for medical purposes only.

Distribution:—Owing to the fact that Japan is a volcanic country, sulphur is found in the volcanic districts extending between Formosa through Kyūshū, Honshū to Hokkaidō and the Kurile Islands. In Formosa, in the vicinity of Mt. Daiton many mines are operated; among them Hokuto is the principal producer. In Kyūshū a few localities are situated along the Kirishima volcanic zone. Sulphur Island and Kujusan are the famous mines among them. In the northern part of Honshū along the Japan Sea side many localities were known to contain sulphur among which Numajiri, Tsurugizan and Uguisuzawa the the principal producers. In Hokkaidō many large mines are operated now, Oshino, Kobui, Iwaonupuri, Kumadomari and Shikabe are the principal producers among them. In the Kurile Islands many localities are known to produce sulphur but only a few of them are being worked at present. Generally speaking, sulphur is one of the most widely distributed minerals in Japan, but it has a special localization in the neighbourhood of volcanos. It is distributed in the northern corner of Formosa, the Inner Side of the North Japan Arc, the eastern part of Hokkaidō, the Kurile Islands and the volcanic zones of Kirishima and Fuji in Kyūshū and Honshū respectively. Among them the major portion of sulphur has been furnished from Hokkaidō, but in the Inner Side of the South Japan Arc, the whole Outer Side of both the North and the South Japan Arc and Sakhalin no active sulphur mine has been found.

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## COAL.

Coal plays a most important rôle in the mineral production of Japan. During the year 1908, 14,688,659 long tons* of coal were produced. In addition to this there were also raised 72,817 long tons† of lignite during the same year.

It might be noted that our coal mining industry is making a substantial progress year by year, as will be seen from the following table :—

TABLE I.

Development of the Japanese coal mining industry by decennial periods.‡

| Year. | Productions. | Value. |
|---|---|---|
| 1877 | 491,835 long tons. | £ 103,649 |
| 1887 | 1,720,909 ,, | ,, 307,701 |
| 1897 | 5,131,628 ,, | ,, 1,909,692 |
| 1907 | 13,736,182 ,, | ,, 6 044,584 |

Coal occurs in 43 of the 49 prefectures of the Japanese Empire, including the island of of Taiwan (Formosa) and the district of Karafuto (Japanese Sakhalin). The following table shows the approximate areas§ of coal fields in the several prefectures and the production in the active prefectures during the year 1907 :

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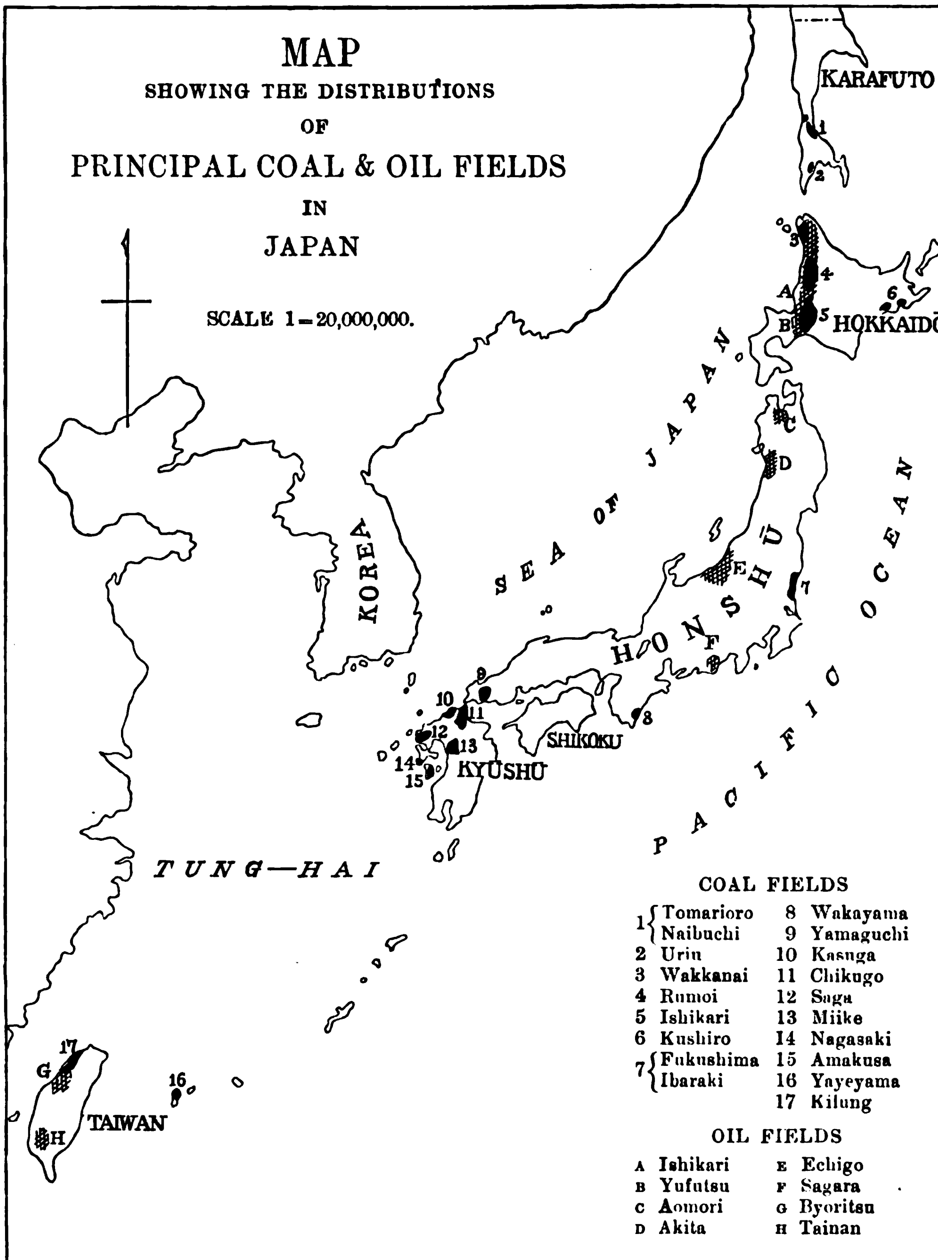
* † and ‡ except Taiwan (Formosa).

§ Estimated according to areas of prospecting and mining concessions of coal fields, known at the and of 1907. The actual coal bearing areas may be larger than the above.

PLATE II.


MAP
SHOWING THE DISTRIBUTIONS
OF
PRINCIPAL COAL & OIL FIELDS
IN
JAPAN
SCALE 1=20,000,000.
KARAFUTO
HOKKAIDŌ
SEA OF JAPAN
KOREA
HONSHŪ
SHIKOKU
KYUSHU
PACIFIC OCEAN
TUNG—HAI
TAIWAN
COAL FIELDS
1 Tomarioro
Naibuchi
2 Urin
3 Wakkanai
4 Rumoi
5 Ishikari
6 Kushiro
7 Fukushima
Ibaraki
8 Wakayama
9 Yamaguchi
10 Kasuga
11 Chikugo
12 Saga
13 Miike
14 Nagasaki
15 Amakusa
16 Yayeyama
17 Kilung
OIL FIELDS
A Ishikari
B Yufutsu
C Aomori
D Akita
E Echigo
F Sagara
G Byoritsu
H Tainan

## Table II.

Coal fields of Japan, by Prefectures and the Production 1907.

| Prefecture. | Approximate Area. Acres. | Active Area. Acres. | Production. long tons. |
|---|---|---|---|
| I.—Kyūshū. | | | |
| Fukuoka | 135,258 | 76,609 | 9,019,510 |
| Saga | 43,094 | 16,616 | 1,027,231 |
| Nagasaki | 47,600 | 16,030 | 485,099 |
| Kumamoto | 42,848 | 3,186 | 71,554 |
| Ōita | 1,382 | — | — |
| Miyazaki | 557 | — | — |
| Kagoshima | 431 | — | — |
| Total | 271,170 | 112,441 | 10,603,394 |
| II.—Hokkaidō | 273,732 | 25,228 | 1,364,830 |
| III.—Honshū (Main Island) | | | |
| 1. Northern Part. | | | |
| Fukushima | 40,202 | 7,704 | 1,026,660 |
| Ibaraki | 18,960 | 3,630 | 170,805 |
| Nagano | 8,975 | 1,770 | 10,861 |
| Yamagata | 6,229 | 2,542 | 6,169 |
| Niigata | 3,614 | 429 | 1,448 |
| Akita | 5,000 | ? | 523 |
| Gumba | 881 | 28 | 262 |
| Iwate | 5,237 | — | — |
| Aomori | 1,158 | — | — |
| Miyagi | 1,143 | — | — |
| Yamanashi | 990 | — | — |
| Saitama | 738 | — | — |
| Tochigi | 729 | — | — |
| Total | 93,856 | 16,103 | 1,216,728 |
| 2. Southern Part of Chūgoku. | | | |
| Yamaguchi | 26,273 | 11,631 | 359,793 |
| Shimane | 2,110 | 819 | 9,941 |
| Okayama | 7,011 | 108 | 356 |
| Hiroshima | 428 | 51 | 306 |
| Total | 35,822 | 12,609 | 370,396 |

| | | | |
|---|---|---|---|
| 3. Middle Part. | | | |
| Wakayama | 1,901 | 987 | 40,414 |
| Miye | 2,994 | 889 | 3,231 |
| Toyama | 622 | 118 | 1,076 |
| Shiga | 358 | 145 | 1,060 |
| Ōsaka | 1,528 | 12 | 435 |
| Gifu | 1,078 | 83 | 234 |
| Ishikawa | 1,266 | 8 | 32 |
| Kyōtō | 3,516 | — | — |
| Nara | 3,470 | — | — |
| Hyōgo | 502 | — | — |
| Aichi | 248 | — | — |
| Fukui | 244 | — | — |
| Shidzuoka | 13 | — | — |
| Total | 17,740 | 2,242 | 46,482 |
| Grand Total | 147,418 | 30,954 | 1,633,606 |
| IV.—Southern Islands. | | | |
| Taiwan | 12,460 | ? | 133,351 |
| Okinawa | 840 | 340 | 6,348 |
| Total | 13,300 | 340 | 139,699 |
| V.—Shikoku. | | | |
| Kagawa | 1,057 | 358 | 988 |
| Tokushima | 700 | 76 | 148 |
| Yehime | 584 | — | — |
| Kōchi | 42 | — | — |
| Total | 2,383 | 434 | 1,136 |
| VI.—Karafuto (Japanese Sakhalin*) | 192,548 | — | — |
| Great Grand Total | 900,550 | 169,397 | 13,736,182 |

The areas of lignite fields in the several prefectures and the production in the year 1907 are given in the next table.

## Table III.

Lignite fields of Japan, and the Production, by Prefectures, 1907.

| Prectures | Approximate Area acres. | Active Area. acres. | Production. long tons. |
|---|---|---|---|
| Aichi | 8,409 | 2,890 | 40,937 |
| Gifu | 6,507 | 1,172 | 16,551 |

* Estimated according to the reconnaissance survey of the Island, 1909.

| | | | |
|---|---|---|---|
| Miyagi | 2,135 | 832 | 6,829 |
| Gumba | 933 | 646 | 2,576 |
| Shiga | 16 | ? | 1,557 |
| Miye | 1,733 | 630 | 985 |
| Hyōgo | 686 | 137 | 200 |
| Fukushima | 130 | ? | 74 |
| Kyōto | 618 | ? | 71 |
| Fukuoka | 42 | ? | 65 |
| Kanagawa | 650 | 243 | 27 |
| Ōsaka | 1,730 | — | — |
| Saitama | 1,360 | — | — |
| Wakayama | 217 | — | — |
| Nara | 161 | — | — |
| Total | 25,327 | 6,550 | 69,872 |

## Geological Sketches of Coal and Lignite Fields.

At the present state of knowledge, the coal-bearing formations of the Japanese islands range in age from Mesozoic to Tertiary.

The Mesozoic coal fields are known in local patches in the following districts: 1. Mine and Toyoura in Yamaguchi (Triassic); 2. Kawakami in Okayama (Triassic?); 3. Kasa and Ikaruka in Kyōto (Jurassic); 4. Katsuura in Tokushima (Jurassic); 5. Ryōseki in Kōchi (Jurassic-Cretaceous); 6. Amakusa in Kumamoto (Cretaceous); 7. Awaji in Hyōgo (Cretaceous); 8. Ōno in Fukui (Jurassic), etc. Among these districts, the comparatively wide and economically important fields are found in the three prefectures of Yamaguchi, Kumamoto and Kyōto.

As a rule, the Mesozoic coal beds have been severely subjected to the tectonic disturbance; so that there are found a large number of faults and contortions of all descriptions. Moreover, they have in many cases suffered from the intrusion of porphyrite, liparite and some younger igneous rocks. The coal is mostly of a semi-anthracitic variety and partly of a semi-bituminous or bituminous coal. Most of the anthracitic varieties are friable and yield a large proportion of slack.

The Tertiary coal fields are widely distributed throughout our Empire from the district of Karafuto (Japanese Sakhalin) on the north to the island of Taiwan (Formosa) on the south. It is most probable that they are visible in the two groups of (1) the older

Tertiary or Eocene-Miocene fields and (2) the younger Tertiary or Pliocene fields.

The older Tertiary coal fields are rather widely distributed and contain a vast reserve of fair bituminous coal. The most productive coal fields of Japan, such as those in Kyūshū, Hokkaidō and the Main Island are known to belong to this group. In the majority of cases, the coal beds of this group have undergone tectonic disturbance which is, however, less in intensity than in those of the Mesozoic age. The coal may be classified as several varieties; such as bituminous coal, semi-bituminous coal, anthracite and lignite, of which the most predominating one is the first named. Such a variation in character may be attributed to the varying degrees of alteration which the coal beds have undergone. The alteration might be produced by the vertical pressure due to the weight of the overlying strata or by the lateral pressure due to the mountain-making forces and by the metamorphisms of intrusive igneous rocks.

The coal beds which come into juxtaposition with the intrusive igneous rocks have almost always produced a coke-like coal. The latter is locally known as "Senseki," "Okori" or "Hashiri," and is particularly abundant in the coal fields of Kyūshū. The intrusive rocks which make their appearance in the form of dykes or sills through the coal beds are locally known as "don," a common term used in Kyūshū. In some cases, the older Tertiary coal beds are characterized by the occurrence of blocks of carbo-silicified wood or "Matsuiwa," so-called by the native miners. They are particularly abundant in some coal beds in Kyūshū.

A certain variety of bituminous coal gives a good coke. Such coking coal occurs, so far as known, in the following fields: In Kyūshū, the Takashima and other fields in Nagasaki Prefecture; the Ochi and some other coal fields in Saga Prefecture; the Miike fields and some other fields in the Chikuhō field, in Fukuoka Prefecture. In Hokkaido, the coal fields of the Yūbari, Sorachi, etc. in the Ishikari Province.

The younger Tertiary coal fields are not so widely distributed as the older. The districts where they occur will be seen in the Table III. already referred to. The tectonic disturbance which the coal beds have undergone is less in intensity than that in the older one. The fuel resource is mostly of a variety called lignite or "Atan" (sub-coal).

Though poor in quality, yet it is largely used for domestic and other purposes.

## PRINCIPAL COAL FIELDS OF JAPAN.

The principal coal fields of Japan may be considered for the sake of convenience under the following divisions: I. the coal fields of Kyūshū; 2. the coal fields of Hokkaidō; 3. the coal fields of Honshū (the Main Island); 4. the coal fields of the Southern Islands; and 5. the coal fields of Karafuto.

I.—The Coal Fields of Kyūshū.

A. Principal coal fields in Fukuoka Prefecture.

1. The Miike Coal Field:—The Miike coal field is located close to the port of Ōmuta, on the east coast of the bay of Ariake. It covers an area of about 30 square miles or more. One half of it is in the province of Chikugo and the other in the province of Higo. The mining concession owned by the Mitsui Mining Company, Tōkyō, occupies almost the whole of the field.

The coal bearing formation is of the Tertiary age (probably Eocene) and consists of an alternation of shale, sandstone and conglomerate. It generally strikes NS or NNW and dips westwards at the angle of 4°—5°, except the eastern part of the field, where the strata undergoes a folding at the contact with the underlaid granite. There are several coal seams known, but two seams only are at present being worked. The first seam averages 8 feet in thickness of pure coal without any partings, the thickest part often rising to thickness of over 20 feet of pure coal. The second seam lies only from 6 feet to 10 feet below the first, and measures about 6 feet in thickness. This seams is being worked only on a limited scale for local consumption. The 8 foot seam yields a high grade bituminous coking coal. The chemical character of the coal will be seen from the annexed analyses:

| Pits. | Moisture. % | Volatile matter. % | Carbon % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|
| Miyanoura | 1.148 | 39.865 | 53.722 | 5.269 | 3.063 |
| Kachidachi | 0.793 | 49.455 | 40.427 | 9.325 | 2.946 |
| Nananra | 1.020 | 40.360 | 51.020 | 7.600 | 5.020 |
| Ōura | 0.879 | 40.332 | 49.219 | 6.570 | 4.052 |

As regards the history and mining methods a description will be given in the later part of the present work. At present, the annual production of the Miike Mine amounts to about 1,500,000 long tons.

2. The Chikuhō Coal Fields: —To the south of Wakamatsu, a well known port for the export of coal, there are a number of productive coal fields, which are known under the general name of "the Chikuhō Coal fields." The coal fields are located in the basins of the Ongagawa and its affluents, i.e. the Kamagawa, Honamigawa, Hikosangawa, etc. which drains the four counties of Tagawa (Buzen), Kaho, Kurate and Onga (Chikuzen). The aggregated area of these fields measures from 21 to 30 miles in length (SSE—NNW) and from 8 to 16 miles in width (nearly WE).

The coal bearing formation is of the Tertiary age. It consists of the alternations of shale, sandstone and conglomerate, and occupies the basin-shaped districts surrounded by the older rocks, such as crystalline schists, Mesozoic sedimentaries and some plutonic rocks. As regards the tectonic condition, this coal bearing Tertiary has to some extents undergone the disturbance by which there occurred a number of faults and some synclinal folds. But generally speaking the strike of the strata varies from NS to NNW, and the dip is in most cases towards the east at angles of from 10° to 20° except in some parts where the disturbance has been much more severe. It is recognized by many geologists that the coal bearing formation is divisible into the groups of the upper and the lower. The lower group is for the most part developed on the southern part of the entire field, or on the upper course of the Ongagawa, including the three counties of Kurate, Kaho and Tagawa. The upper group, on the other hand, covers the northern part of the entire field or is developed in the county of Onga on the lower course of the Ongagawa. In both groups there are intercalated several numbers of coal seams. In the lower group, the seams are generally thick and yield high-grade bituminous coal. There are a number of workable seams known among which the most important are the Four-foot-seam (3—6 feet) and the Five-foot-seam (4—8 feet). These two principal seams and the other annexed seams are known under different names at different collieries. They contain in most cases the carbosilicified wood or "Matsuiwa," which occur mostly in round blocks, large or small, scattered in the coal beds. In some cases, they have suffered from dydes or sills of andesite and basalt, which have altered the coal coming in contact with them into a natural coke and the allied matter, known as "Senseki," "Okori," "Hashiri," etc., while such intrusive dykes and sills are well known under the local name of "Don," and are of frequent occurrence in the southern parts of the Tagawa and Kaho districts.

In the upper group, on the other hand, the coal seams are generally thin, compared with those in the lower group, measuring from 1.6 to 3 feet in thickness. There are seven principal seams. As to the tectonic condition, the seams of this group are not so intensely disturbed as are those in the lower. They are also characterized by the scarcity of the "Matsuiwa" and the entire absence of the "Don."

The following analyses show the composition of the coal mined in some collieries of the "Chikuhō" fields:—

Analyses of Coals from the Lower Group.

| Colliery. | Seam. | Moisture. % | Volatile matter. % | Carbon. % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|---|
| Akaike | Five-foot-seam | 2.64 | 43.99 | 50.44 | 2.93 | 0.41 |
| Hōkoku | Eight-foot ,, | 1.70 | 45.67 | 50.76 | 1.87 | 0.36 |
| Mineji | Eight-foot ,, | 3.30 | 39.94 | 53.48 | 3.25 | 1.19 |
| Meiji | Five-foot ,, | 2.28 | 38.21 | 48.23 | 11.28 | 0.79 |
| Hondō | Five-foot ,, | 2.84 | 42.59 | 52.71 | 1.86 | 0.35 |
| Daibu (Shinyama) | Five-foot ,, | 1.70 | 43.96 | 50.34 | 4.00 | 1.51 |
| Takao | Five-foot ,, | 1.68 | 41.04 | 48.65 | 8.63 | 1.02 |
| ,, | Four-foot ,, | 2.50 | 37.42 | 50.11 | 9.97 | 0.27 |
| Namadzuta | Doran-five-foot-seam | 1.41 | 41.34 | 51.54 | 5.71 | 0.38 |
| ,, | Chirimen-five-foot ,, | 1.66 | 42.50 | 52.68 | 3.16 | 0.81 |
| Shakano-o | Five foot-seam | 2.47 | 41.61 | 52.31 | 3.61 | 0.81 |
| Katsuno | Five-foot ,, | 1.08 | 43.75 | 52.81 | 2.36 | 0.65 |
| Ōnoura | Five-foot ,, | 1.28 | 43.28 | 47.86 | 7.58 | 2.82 |
| ,, | Three-foot ,, | 2.60 | 41.16 | 51.43 | 4.81 | 0.33 |
| Shin nyū | Three-foot ,, | 3.41 | 42.76 | 48.46 | 5.37 | 0.22 |

Analyses of Coals from the Upper Group.

| | | | | | | |
|---|---|---|---|---|---|---|
| Ōtsuji | Onedo | 6.04 | 41.66 | 49.24 | 3.06 | 0.72 |
| Arate | Miyeda | 5.06 | 43.70 | 44.10 | 6.60 | 2.53 |
| Ōkuma | Takaye | 4.16 | 46.39 | 46.19 | 3.26 | 0.38 |

Analyses of the "Senseki."

| | | | | | |
|---|---|---|---|---|---|
| Tagawa | 3.92 | 7.17 | 73.99 | 14.92 | 0.27 |
| Kaho | 2.60 | 5.40 | 79.20 | 12.80 | 0.42 |
| ,, | 1.50 | 2.20 | 81.70 | 5.60 | 0.59 |

The coal which gives a good coke is mined from some coal beds in the lower group, and is particularly developed at Daibu, Iidzuka (Futase and Chinsei), Shakano-o, Miyada, etc. on the west side of the Ongagawa and Honamigawa.

There are at present a large number of collieries, among which those producing over 30,000 long tons annually are known to be the following :—

| County. | | Colliery. |
|---|---|---|
| Onga | | Ōtsuji |
| ,, | | Miyoshi |
| ,, | | Daini-Arate |
| ,, | | Iwasaki |
| ,, | | Takamatsu |
| Kurate | | Ōnoura |
| ,, | (Partly in Onga) | Shin-nyū |
| ,, | (Partly in Kaho) | Shiogashira and Shakano-o. |
| ,, | (Partly in Kaho and Tagawa) | Meiji |
| ,, | | Mitsui Hondō |
| ,, | | Kaigun-Gotoku |
| ,, | | Koyanose |
| ,, | (Partly in Onga) | Koyanose (Arima's) |
| Kaho | | Futase (Takao, Ikisu and Uruno) |
| ,, | | Namadzuta |
| ,, | | Yoshio |
| ,, | | Mameda |
| ,, | | Mitsui-Yamano |
| ,, | | Aida |
| ,, | (Partly in Tagawa) | Kamiyamada |
| ,, | | Shimoyamada |
| ,, | | Muta |
| ,, | | Tadakuma |
| ,, | | Hirayama |
| ,, | | Honami |
| ,, | | Kumata |
| ,, | | Akaji |
| Tagawa | | Mitsui-Tagawa |
| ,, | | Kanada |
| ,, | | Hōkoku |
| ,, | | Ōtō |
| ,, | | Akaike |
| ,, | | Miyazaki-Hōshū |
| ,, | | Miyao |
| ,, | | Soyeda |
| ,, | | Kahara |
| ,, | | Mineji |

| | |
|---|---|
| Tagawa | Hon-Soyeda |
| " | Gōtōji |
| " | Kanaya-Dai-Nikō |

3. The Kasuya Coal Field:—This field is located to the east of the city of Fukuoka and is accessible by a railway by which it is connected with the port of Hakata and some other ports. The coal bearing Tertiary strata occupies a limited basin surrounded by Palaeozoic and older granite. The basin is divided into two parts: the northern and the southern. In each part, the seams have undergone a cynclinal folding. The workable seams are two in number, each measuring from 2 to 5 feet in thickness. The character of the coal is of a high grade of bituminous coal. The following are the analyses of the coal mined there:—

| Colliery. | Moisture. | Volatile matter. | Carbon. | Ash. | Sulphur. |
|---|---|---|---|---|---|
| Tsubakuro | 3.20 | 36.96 | 51.09 | 8.75 | 0.53 |
| Shimbaru | 3.36 | 41.13 | 48.44 | 7.07 | 0.38 |

Among the collieries now under operation, those producing over 30,000 long tons annually are the followiug: Tsubakuro, Sasaguri, Shimbaru Kaigun, and Uyeki.

B. Coal Fields in Saga Prefecture.

In the prefecture of Saga, province of Hizen, there are a number of collieries in the counties of Higashi-Matsura, Ogi, Kishima, Nishi-Matsura and Fujitsu. The coal bearing formation is of the Tertiary age and consists of sandstone and shale. It occurs in low or hilly districts surrounded by mountains of old granite and young volcanic rocks, and has to a certain extent suffered from tectonic disturbances. There are several coal seams, among which those workable are two or three. They are generally thin in thickness, rarely exceeding over 5 feet. The coal is of a bituminous variety of which some give a fair coke, as known at Ōchi, Kitagata, etc. The following are the analyses of the coal mined in some of the collieries:—

| District. | Colliery. | Moisture. | Volatile matter. | Carbon. | Ash. | Sulphur. |
|---|---|---|---|---|---|---|
| Higashi-Matsura | Yoshinotani | 2.60 | 43.45 | 48.17 | 5.78 | — |
| " | Ōchi | 3.55 | 40.17 | 53.21 | 3.07 | 0.75 |
| " | Kishitake | 4.10 | 43.13 | 47.31 | 5.46 | 2.42 |
| " | Iwaya | 2.20 | 43.16 | 49.62 | 5.02 | 2.27 |
| Kishima | Kishima | 3.39 | 40.90 | 48.76 | 6.97 | 2.81 |

Among the collieries now under operation, the following mines are known to be principal ones.

| District. | Colliery. |
|---|---|
| Higashi-Matsura | Yoshinotani |
| " | Ōchi |
| " | Kishitake |
| Ogi | Yunokibara |
| Kishima | Akasakaguchi |
| " | Kinoshima |
| Kishima—Ogi | Kishima-Dai-nikō |
| " | Kitagata |

C. Coal Fields in Nagasaki Prefecture.

In the prefecture of Nagasaki, the coal bearing Tertiary formation is developed in the three counties of Kita-Matsura, Higashi-Sonoki and Nishi-Sonoki.

1. Kita-Matsura and Higashi-Sonoki Fields:—The coal field of Kita-Matsura and Higashl-Sonoki is the western continuation of that in the above-mentioned Saga Prefecture. There are a number of collieries working thin coal beds. At present, the most productive colliery is the Matsura Mine. Here, the seam 2 feet thick is being worked, the output in 1907 being reported as 68,425 long tons.

2. The Coal Fields in Nishi-Sonoki:—In the county of Nishi-Sonoki, the coal beds are exposed in a detached manner on the several islands off the west sea-coast. Among the collieries now under operation, the most productive one is the famous Takashima colliery, including a branch mine on the Hashima Island. There are several seams among which five or six seams are capable of being worked. At Takashima they strike generally NEE and dip towards NWW at an angle of 20°—25° on the north-eastern part of the island and 30°—50° at the south-western part. At Hashima, the dip is more steep, reaching 60°—70° at the south-western part of the island. The coal is bituminous, being high grade in quality. The following are the analyses of some coals mined there.

| Seam. | Moisture. | Volatile matter. | Carbon. | Ash. | Sulphur. |
|---|---|---|---|---|---|
| Upper-eight-foot | 1 22 | 39.88 | 55.50 | 3.40 | 0.25 |
| Goma-five-foot | 1.10 | 42.08 | 54.38 | 2.44 | 0.11 |
| Banto | 1.54 | 37.15 | 59.07 | 2.33 | 0.12 |
| Eighteen-foot | 1.10 | 36.95 | 59.94 | 2.01 | 0.10 |

Takashima coal mine gives the best coke. Details of the mining method at present will be given in the latter part of this paper.

### D. Coal Fields in Kumamoto Prefecture.

In the prefecture of Kumamoto, the most important coal producer at present is Shimoshima, on one of the Amakusa Islands. There, the coal bearing formation is developed on the western half of the island. It consists of an alternation of shale, sandstone and conglomerate, and strikes generally NNE, though the strata have been much disturbed. A large number of faults and contortions are met with. The known coal seams are three in number. As regards the thickness, the upper seam varies from 8 to 6 feet; the middle seam 1 to 3 feet and the lower one from 5 to 4 feet. The coal is of an anthracite variety. It is black in colour and has a submetallic lustre and is well known under the local name of "Kiratan." Occasionally there occurs a variety called "Kawarake," a greyish or greyish-black coal with no metallic lustre. It is loose, earthy or sometimes porous, and may be styled a natural coke. This altered coal is found at the contact with porphyrite and basalt which have intruded through the coal beds. Such eruptive rocks are decomposed in most cases into white or light-greyish matter, and are locally known as "Shiro". The following are the analyses of some samples of the "Kiratan" and "Kawaraketan":

Analyses of "Kiratan."

| District. | Seam | Moisture. | Volatile matter. | Carbon. | Ash. | Sulphur. |
|---|---|---|---|---|---|---|
| Uonuki | Gemgenyama-two-foot | 1.12 | 13.62 | 82.24 | 3.03 | 0.82 |
| " | Hirnyama-five-foot | 1.67 | 10.67 | 83.89 | 3.77 | 0.50 |
| " | Uragoye-five-foot | 1.42 | 11.59 | 82.98 | 4.61 | 0.60 |
| Itchoda | Otashiro-two-foot | 4.03 | 14.29 | 65.75 | 15.93 | 4.52 |
| " | Asahi-two-foot | 2 27 | 14.73 | 77.16 | 5.84 | 2.58 |

Analyses of "Kawaraketan."

| District. | Moisture. | Volatile matter. | Carbon. | Ash. | Sulphur. |
|---|---|---|---|---|---|
| Nogami | 1.67 | 8.49 | 85.59 | 4.52 | 1.85 |
| Itchoda | 3.23 | 2.56 | 90.89 | 3.32 | 1.47 |

The "Kiratan" is mostly used for the fuel of lime and cement manufacture. The "Kawaraketan" is chiefly used for coke.

The production in 1907 was reported as 71,415 long tons.

## II.—Coal Fields of Hokkaidō.

I. The Ishikari Coal Fields:—Hokkaidō ranks second in the priority of coal production. The most productive coal fields on the island at present are those lying to the east of the city of Sapporo, in the province of Ishikari. The aggregsted area of these fields extends for a distance of about 50 miles in NS direction, with an average width of some 12 miles. It is traversed by some rivers such as the Yūbari, Poronai, Bibai and Sorachi, all being the affluents of the Ishikari. Along each of these rivers, the coal bearing region is touched by railways and thus it is separated into several mining districts, such as Yūbari, Poronai, Bibai, Utashinai, etc.

The coal bearing formation consists of an alternation of shale and sandstone, probably of the Eocene-Miocene age. It strikes nearly NS though it has suffered much from tectonic disturbance, which seems to have been more severe on the northern part where the coal beds have undergone nearly vertical inclination. There are a number of workable seams, among which those that have been hitherto worked are at times from two to ten. The thickness varies from 3 feet to 5 feet in each seam. Sometimes there occurs a seam which measures 25 feet or more in its thickest part. The coal is a high grade bituminous variety, of which a certain kind produces a good coke. The percentage of slack is generally small, except in Sorachi colliery. The following are the analyses of some coals mined in these fields.

| Colliery. | Moisture. % | Volatile matter. % | Carbon. % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|
| Yūbari | 1.218 | 42.235 | 51.502 | 4.573 | 0.472 |
| Sorachi | 1.623 | 30.051 | 60.553 | 7.504 | 0.264 |
| Poronai | 1.270 | 36.610 | 55.980 | 4 240 | 0.590 |
| Ikushunpets | 1.770 | 47.880 | 42.550 | 7.640 | 0.160 |

Details of the mining methods will be given later in this paper. The following are the principal mines now under operation in this coal region such as Yūbari No. 1, and No. 2, Shin-Yūbari, Sorachi, Poronai, Ikushunpets and Pompets.

Besides the Ishikari coal fields above described, there are a number of coal fields in the other provinces, most of which are not yet fully explored. Among them are the following:

1. Rumoi coal fields in Teshio.
2. Haboro coal fields in Teshio.
3. Wakanai, or Sōya coal fields in Kitami and Teshio.
4. Poropets coal field in Iburi.
5. Makunpets coal field in Hidaka.
6. Akkeshi coal field in Kushiro, etc.

III.—Coal Fields of Honshū (Main Island).

The productive coal fields in Honshū at present may fall into following three divisions:

1. The coal fields in Fukushima and Ibaraki.
2. The coal fields in Yamaguchi.
3. The coal fields in Wakayama.

1. The Coal Fields in Fukushima and Ibaraki Prefectures: —To the north-east of Tōkyō, there lies a coal producing region along the Pacific Sea board, which extends for a distance of some 52 miles in nearly NS direction from the village of Tomobe in the county of Taga in Ibaraki to Nogami in the county of Futaba in Fukushima. This coal region is well known under the name of the "Jōban," or Hitachi and Iwaki coal fields, and ranks third in the priority of the production of coal in Japan. The coal bearing formation is of the Tertiary age and consists of an alternation of tufaceous shale and sandstone. It strikes nearly NS or N 30° E, with a gentle easterly dip, though it is variable here and there. There are several coal seams, but only one or two of them have been hitherto worked. The thickness of the workable seams varies from 3 to 7 feet. In most cases they are more or less disturbed by the mountain making pressure, giving rise to a number of faults. The coal is for the most part of an intermediate variety between lignite and bituminous coal, which gives no coke. The chemical character is as follows:—

| Colliery. | Moisture % | Volatile matter. % | Carbon. % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|
| Iriyama | 7.05 | 40.88 | 35.36 | 16.71 | 1.80 |
| Onoda | 9.54 | 44.31 | 38.53 | 7.28 | 0.41 |
| Shiramidzu | 5.70 | 45.60 | 39.98 | 9.99 | 1.48 |

| | | | | | |
|---|---|---|---|---|---|
| Miya | 7.87 | 44.88 | 35.02 | 7.26 | 2.16 |
| Yoshima | 7.58 | 42.50 | 34.65 | 6.95 | 0,37 |

The principal collieries are:—

| Prefecture. | Colliery. |
|---|---|
| Fukushima | Onoda |
| " | Iriyama |
| " | Uchigō |
| " | Yoshima |
| " | Ōjō |
| " | Sansei |
| " | Sumidagawa |
| Ibaraki | Ibaraki-Muen |
| " | Ibaraki-Saitan |
| " | Koshiga |

2. Coal fields in Yamaguchi Prefecture:—In the province of Nagato, the southern extremity of Honshū there are some coal producing districts in the counties of Mine, Asa and Toyora. Here the coal is of two varieties: one is anthracitic and the other is brown coal.

a. The Anthracite fields:—The anthracite is found in Mesozoic (Triassic) formation made up of sandstone, conglomerate and shale. Through the formation there occur dykes of liparite and porphyrite. The workable coal seams are three in number and each measures from 2 feet to 5 feet or sometimes 8 feet. Some coal beds are traced for about 5 miles on the outcrop. They dip at high angles and are much disturbed. The coal is of a semi-bituminous variety and that coming in contact with the intrusive rocks is altered into so-called "Senseki." The semi-anthracite is usually friable and yields a large percentage of slack. The chemical composition will be seen from the following analyses:

| Localities. | Moisture. % | Volatile matter. % | Carbon. % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|
| Hieda | 5.22 | 4.32 | 71.67 | 18.79 | 0.62 |
| Mugikawa | 2.25 | 10.67 | 64.82 | 22.26 | 0.62 |
| Arakawa | 1.96 | 17.06 | 66.74 | 14.24 | 0.43 |
| Tsubuda | 5 70 | 3.50 | 71.69 | 19.11 | 0.22 |

The most productive colliery is Ōmine mine, operated by the Navy Department; and its production in 1907 was reported as

61,622 long tons. The coal mined is conveyed to Tokuyama in the province of Suō where it is made into briquettes, while the coal mined in other collieries is largely used for lime burning and some other purposes in the neighbouring districts.

b. The Brown Coal field:—In the county of Asa, there are found several collieries working the brown coal contained in the younger Tertiary strata, made up of soft sandstone and shale. The dip is gentle, the angle not exceeding 10°. There are three or four seams, each one measuring from 1 to 2 feet in thickness. The chemical character of the coal will be seen from the following analyses:

| Seam. | Moisture. % | Volatile matter. % | Carbon. % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|
| Futaishi | 8.62 | 39.16 | 36.31 | 15.91 | 3.33 |
| Shichika | 8.25 | 38.31 | 36.46 | 16.98 | 1.09 |
| Hitoishi | 8.83 | 43.18 | 40.28 | 7.71 | 2.93 |
| Nakabori | 8.42 | 44.52 | 37.08 | 9.98 | 0.94 |

The chief collieries are Okinoyama, Kamihara, Misome and so on.

3. The Coal Fields in Wakayama Prefecture.—In Wakayama Prefecture, there lies an important coal region along the west bank of the Totsugawa or Kumanogawa about 10 miles north of Shingū, a town on the Pacific Sea board. The coal bearing formation is of the Tertiary age and consists of shale and sandstone (partly conglomeratic). It strikes generally N 20°—60° E and dips south-east at an angle of 10°—18°. In the neighbouring district there occur large masses of liparite which have risen up through the sedimentaries. One workable seam is known intercalated in shale; the thickness varying from 1 feet to 4 feet. Coal is of an anthracite variety being black in colour and having sub-metallic lustre: specific gravity 1.5; hardness 2.5; the percentage of slack is low or 3.9 per cent. The following is the analysis of the coal:

| Moisture. | Volatile matter. | Carbon. | Ash. | Sulphur. |
|---|---|---|---|---|
| 7.41 | 1.70 | 87.26 | 3.63 | 2.49 |

The chief mines now operated are Miyai, Okudani, Otogawa, Senshōdake and Mansai.

IV.—Coal Fields of the Southern Islands.

1. Taiwan or Formosa.—In Taiwan, coal occurs in several districts on the western and northern parts of the island, and also in Hokuto, a small island off the west coast. The coal bearing formation is of the Tertiary age and cousists of sandstone or shale. There are a number of coal seams, among which those workable number two or three. They are thin in width, measuring from 2.5 to 3.6 feet each. The dip is variable in different districts; at some places 5°—16° and at others 29°—50°. The coal is mostly of a bituminous variety. The following analyses show the character of the coal in the several localities:—

| Localities. | Moisture % | Volatile matter. % | Carbon. % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|
| Kilung | 3.86 | 37.37 | 55.01 | 4.06 | 1.91 |
| " | 6.43 | 38.83 | 51.11 | 3.63 | 0.69 |
| Daihoku | 1.12 | 41.66 | 50.49 | 1.23 | 3.52 |
| Tōyen | 1.66 | 38.01 | 58.06 | 2.27 | 1.15 |
| Shimkō | 5.23 | 40.60 | 51.72 | 2.44 | 3.54 |
| Shinchiku | 3.92 | 53.11 | 33.67 | 9.88 | 2.51 |
| Daitchū | 5.24 | 41.00 | 47.25 | 5.10 | 1.41 |
| Daitō | 14.50 | 41.25 | 40.50 | 3.75 | trace. |

The total output of coal in 1907 was reported as 133,351 long tons. This output shows that the mining industry has made there recently a great progress, when compared with that of 19,746 long tons in 1897.

2. Okinawa.—In Okinawa Prefecture, coal occurs on the island of Yayeyama, one of the Loochoo islands. The coal bearing formation is of Tertiary age and consists of shale and sandstone. One workable seam is known 4 feet thick. The coal is of a good bituminous variety, the analysis of a sample being as follows: moisture 2.19; volatile matter 41.50; carbon 51.86; ash 4.51; sulphur 2.33. The output in 1907 was reported as 6,348 long tons.

V.—Coal Fields of Karafuto (Japanese Sakhalin).

In Karafuto or Japanese Sakhalin, recent explorations have shown that there exist a number of coal beds on the several waterways; such as the Uryū, the Pustaki, the Naibuchi, the Poronai, etc., on the Okhotsk Sea side, and the Nayashi, the Tokombo, the Otekoro, the Tomarioro, the Serutonai, etc. on the Japan Sea board. The total area, so far as known, is roughly estimated at 192,547 acres. This estimate will undoubtedly increase, when the island will have been explored more throughly.

The coal bearing formation is of the Tertiary age. It consists of shale, sandstone and conglomerate. The dip is in most cases from 20° to 50°. There are several coal seams measuring over 3 feet in thickness; some few measuring over 10 feet. The coal is of two varieties: bituminous coal and lignite. The following analyses show the chemical composition of some of the high grade coals so far explored;

| Districts. | Moisture. % | Volatile matter. % | Carbon. % | Ash. % | Sulphur. % |
|---|---|---|---|---|---|
| Poronai | 14.350 | 30.075 | 52.400 | 2.475 | 0.610 |
| Serutonai | 1.165 | 24.778 | 70.065 | 3.030 | 0.961 |
| Tomarioro | 5.120 | 4.280 | 48.910 | 3.630 | 0.290 |
| Naibuchi | 6.250 | 43.538 | 46.970 | 2.300 | 0.912 |

At present, none of the fields are as yet practically touched, owing to the lack of transportation facilities and shipping harbours. But several attempts are now being undertaken by the Government for exploitation of the most important mineral resources of the Island.

## GRAPHITE.

The yearly production of graphite has fluctuated from 195,000 to 480,000 lbs. since the year 1900, but the domestic demand has gradually increased year after year and in 1908 the output was 262,337 lbs. valued at £1,200, the increment being 33,045 lbs. compared with that of the previous year. This output is too small to supply the domestic demand and the most part of graphite consumed in Japan is imported annually from Korea, Ceylon, etc. In 1907 the imports amounted to 3,343,978 lbs. valued at £13,626 and the exports were 2,113,921 lbs. valued at £3,223. The outputs of the principal mines during 1907—1908 are given as follows:—

| Mines. | Provinces. | 1908. Pounds. | 1908. Value. | 1907. Pounds. | 1907. Value. |
|---|---|---|---|---|---|
| Naoi | Hida | 85,333 | £832 | 81,200 | £791 |
| Sen-noya | Etchū | 16,268 | 107 | 20,000 | 135 |
| Yoneyama | Satsuma | 17,100 | 86 | 17,013 | 89 |
| Yamamune | Rikuzen | 133,750 | 62 | 119,674 | 57 |
| Konishi | Etchū | 12,630 | 59 | 2,666 | 10 |
| Takashimidzu | ,, | 22,932 | 41 | 6,400 | 24 |
| Amo | Hida | — | — | 4,666 | 45 |

Ores:—Graphite occurs in two forms the crystalline and amorphous. The former is commonly found in scales, while the latter is massive often shaly in its character.

Deposits:—There are two types of deposits (1) Bed-like deposits and (2) Vein-like deposits. The examples of the former type are very numerous, but those of the latter are very rare. Among the former type two kinds of ores are observable, i.e. (a) crystalline scales in Archean gneiss and (d) amorphous masses in Palaeozoic slate or in Mesozoic shale. In the latter type one example is known to occur in liparite where the ore is of a supperior quality to that of the former type.

The relations between the characters of ores and the geology of the principal mines are as follows:—

| Mines and localities. | Provinces. | Ores. | Desposits. | Geology. |
|---|---|---|---|---|
| Naoi | Hida | Crystalline | Bed | Archean gneiss. |
| Amo | ,, | ,, | ,, | ,, ,, |
| Senoya | Etchū | ,, | ,, | ,, ,, |
| Yamamune | Rikuzen | Amorphous | ,, | Palaeozoic slate. |
| Kōsei-mura | Nagato | ,, | ,, | Mesozoic shale sometimes caught up by quartz-diorite. |
| Yoneyama | Satsuma | ,, | ,, | Mesozoic shale caught up by andesite. |
| Kataya | Kaga | ,, | Vein | Liparite. |

Distribution:—It is the most abundant in gneissic regions as in the provinces of Hida, Etchū, Mikawa and Ise. Among them the first two are the chief localities and the mines are operated where scaly graphite occurs as a constituent mineral of the country rock. The most part of the production of graphite in Japan comes from this source. At Yamamune in Rikuzen thick amorphous graphite is imbedded in Palaeozoic slate and at Kōsei-mura in Nagato a thin bed of graphite forms a Mesozoic strata and a portion of this bed was caught by quartz-diorite erupted in them. A similar occurrence is found at Yoneyama in Satsuma where the intruded rock is andesite instead of quartz-diorite. It has been said that the graphite was formerly a coal seam that has been metamorphosed by the heat of the intrusive rock. In the island of Shimo-Koshiki in the same province a graphite stratum is found in the cretaceous shale. At Kataya in Kaga lenticular graphite is found in a clay vein of liparite. Owing to its good quality it was used for the manufacture of pencils.

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## PETROLEUM.

The oil-fields are widely distributed in the Empire, a large continuous oil-belt being formed along the inner side of North Japan. It extends from the west coast of Sakhalin in the north, through the west side of the central mountain range of Hokkaidō, along the coast of the Sea of Japan in the main land, stretching over the provinces of Mutsu, Ugo, Uzen, Echigo and Shinano, to the Pacific coast of Tōtōmi province in the south, while in Formosa an oil-field occurs near the west coast.

The following is a tabular statement of the annual production of crude oil in the Empire during the past twenty years from 1888 to 1907 (1 barrel = 42 gallons).

| Year. | Total production of crude oil in barrels. | Year. | Total production of crude oil in barrels. |
|---|---|---|---|
| 1888 | 45,006 | 1895 | 169,873 |
| 1889 | 63,490 | 1896 | 236,819 |
| 1890 | 61,817 | 1897 | 262,751 |
| 1891 | 63,618 | 1898 | 319,015 |
| 1892 | 82,833 | 1899 | 539,098 |
| 1893 | 106,983 | 1900 | 871,740 |
| 1894 | 172,711 | 1901 | 1,117,995 |

| | | | |
|---|---|---|---|
| 1902 | 997,543 | 1905 | 1,352,574 |
| 1903 | 1,210,340 | 1906 | 1,571,867 |
| 1904 | 1,220,744 | 1907 | 1,727,298 |

Referring to the upper table, it is seen that our oil industry has made the most rapid progress, the proportion of the increase of oil production being so estimated that the amount of 1907 appears to be about seven times compared with that of 1897, ten years ago, and about thirty-one times compared to that of 1890, seventeen years ago.

This development of our oil industry has been mostly due to the improvement of the method of drilling, that is to say, by the use of the American rope drilling. This drilling was first put into practical operation in the fall of 1890, at the Amaze district in Echigo province, by the Nippon Oil Company, and as the result, a spouting well was struck at the beginning of the following year. Up to this time, the primitive method of the hand dug wells had been used everywhere, while consequent to this success, numerous oil-wells have been sunk successfully in this district by the new method. The rapid increase of the oil production in 1894 was owing to the conspicuous development of the Amaze district. In the next year 1895, the output from the Amaze district inclined to diminish, but the success of the Higashiyama oil-field in 1894 and the subsequent success of the Nishiyama oil-field in 1898, the Kubiki oil-field in 1900, and the Ojiya oil-field in 1902 are the causes of the increase of the annual production since 1896. Under a series of development, the oil production after a few years was raised up to more than 1 million barrels in 1901; and the most recent increase of the production is a result of the extensive development of the Niitsu oil-field and of the deep boring in the Miyagawa district in the Nishiyama oil-field.

Besides these causes, the researches of many oil-filds, especially those conducted by the Oil Land Survey of the Government which had worked on several oil-fields of Echigo and Hokkaidō since 1900, are to be counted as a cause of the development.

The oil-fields that are now yielding petroleum are as follows:

| Name of Provinces. | Name of Oil-fields. |
|---|---|
| Hokkaidō | Ishikari. |
| " | Yūfutsu. |
| Ugo | Akita. |

| | |
|---|---|
| Echigo | Higashiyama. |
| „ | Nishiyama. |
| „ | Kubiki. |
| „ | Niitsu. |
| „ | Ojiya. |
| „ | Yoneyama. |
| „ | Gōtsu. |
| „ | Hiyama. |
| „ | Kurokawa. |
| Shinano | Nagano. |
| Tōtōmi | Sagara. |
| Formosa | Byōritsu. |

In these oil-fields, the chief centers of activity are in Echigo province, the output contributing about 99 per cent. of the total production as stated in the following list:

| Year. | Annual production of crude from there fields in barrels. | Ditto from other provinces in barrels. |
|---|---|---|
| 1904 | 1,215,548 | 5,196 |
| 1905 | 1,337,861 | 14,713 |
| 1906 | 1,556,980 | 14,387 |
| 1907 | 1,711,608 | 15,690 |
| 1908 | 1,864,643 | 7,949 |

Considering these circumstances it may be stated that the oil industry of Japan is practically is that of Echigo.

Among the above mentioned oil-fields of Echigo, the most productive are Higashiyama, Nishiyama, Kubiki, Niitsu and Ojiya. As the percentage of the annual production from these oil-fields to the total production from Echigo is stated by the following table, the amount of more than 90 per cent. of the total production from Echigo is extracted from the three oil-fields of Higashiyama, Nishiyama and Niitsu.

The annual productions from the main oil-fields of Echigo are represented in percentage as follows:—

| Year. | Higashiyama Oil-field. | Nishiyama Oil-field. | Niitsu Oil-field. | Kubiki Oil-field. | Ojiya Oil-field. | Other Oil-fields. |
|---|---|---|---|---|---|---|
| 1903 | 31.4 | 28.7 | 29.3 | 8.6 | 1.7 | 0.3 |
| 1904 | 26.4 | 23.7 | 42.6 | 5.5 | 1.5 | 0.3 |
| 1905 | 20.8 | 21.3 | 48.6 | 7.5 | 1.1 | 0.2 |
| 1906 | 20.2 | 20.0 | 53.6 | 5.1 | 0.7 | 0 3 |
| 1907 | 19.5 | 21.3 | 54.8 | 3.6 | 0.4 | 0.4 |

Until ten years ago, the oil industry had been conducted by a large number of companies and private individuals worked on a small scale, but they have recently been amalgamated into a few companies and individuals. The chief oil companies at present are the Nippon, the Hōden, the Chūō and the Nakano. It will be observed, on inspection of the attached list, that the production of the Hōden and the Nippon oil companies occupy about 86 per cent. in the total amount of oil from Echigo, while 14 per cent. is secured by the other two oil companies.

| Name of Company. | Output of oil from Echigo in 1908. (in barrels.) |
|---|---|
| Hoden | 884,618 |
| Nippon | 583,848 |
| Chūō | 62,400 |
| Nakano | 103,026 |
| Others | 230,751 |
| Total | 1,864,643 |

The geological formation of the oil-fields belongs exclusively to the Tertiary formation. It is generally divided into the three series as follows :—

(1). The upper series which consist of many layers of clayey shale, sandstone and conglomerate.

(2). The middle series which consist of sandy shale, sometimes interlined with thin layers of sandstone.

(3). The lower series.

a. The upper part consists of alternate layers of sandstone and shale.

b. The lower part consists of shale interspaced with many layers of standstone, tuff and tufaceous sandstone.

The oil-bearing beds are sandstone and tuff interlaid between the layers of the impervious shale of the middle or lower series, or sometimes the shale itself. The depths of the oil-bearing strata and the densities of crude oil are as follows ;—

| Name of Provinces. | Name of oil-fields. | Depth of oil bearing bed in feet. | Degree in Baumé. |
|---|---|---|---|
| Hokkaidō | Ishikari | 1,200–2,100 | 37° |
| „ | Yufutsu | 60–120 | 22° |
| Ugo | Akita | 900–1,380 | 20°-30° |
| Echigo | Higashiyama (Shallow beds) | 600–900 | 20°-32° |
| „ | „ (Deep bed) | 1,938 | 38° |
| „ | Nishiyama, | | |
| | Kamada-Nagamine (1st bed) | 600-780 | 23°-72° |
| | „ „ (2nd bed) | 960 | 30°-36° |
| | „ „ (3rd bed) | 1,500 | >35° |
| | Miyagawa (1st bed) | 1,020-1,320 | 32°-35° |
| | „ (2nd bed) | 1,860-2,040 | 43°-45° |
| | Amaze | 1,200-1,800 | 38°-42° |
| | Nanokaichi | 420–480 | 16° |
| | Myōhōji | 420–480 | 35°-38° |
| „ | Niitsu | 540–720 | 13°-20° |
| „ | Kubiki, | | |
| | Hara-Iwagami | 600–900 | 40°-45° |
| „ | Gendōji | 360–900 | 38°-43° |
| „ | Ojiya | 660-1,140 | 43°-50° |
| „ | Yoneyama, | | |
| | Hassaki | 600–780 | 43°-46° |
| | Byodōji | 780 | 45°-48° |
| „ | Gōtsu | 2,040 | 40° |
| „ | Hiyama | 270-480 | 31°-42° |
| „ | Kurokawa | 60–240 | 22° |
| Shinano | Nagano | 180–240 | 21° |
| Tōtōmi | Sagara (1st bed) | 360–540 | 43° |
| „ | „ (2nd bed) | 720–1,085 | 43° |
| Formosa | Byōritsu (1st bed) | 360–540 | 37°-40° |
| „ | „ (2nd bed) | 900 | |

For the boring of oil-wells, the American rope system is now adopted everywhere. The prevalent depth of the wells being from 600 to 1,200 feet, the derrick is from 40 feet to 60 feet in height and the casing from 4¼ to 8 inches in diameter are common. But recently the deep holes of more than 2,000 feet in depth being used in several oil-fields, the high derrick from 70 to 85 feet, and the large casing from 12 to 14 inches in diameter came to be welcomed. The deepest well at the present time is that of 2,800 feet in the Gōtsu oil-field.

Beside the American rope drilling, the two methods which are called "Tebori" and "Kadzusabori" are sometimes employed in some oil-fields. "Tebori" or hand dug well is a primitive method, sinking a square pit 4 to 6 feet in width. This well is used in such places, where oil-bearing bed is very shallow, where thin layers yielding oil exist, or where the surface water is rare. The depth of the wells of this kind is less than 600 feet, and it is commonly found to be very difficult to work them deeper.

"Kadzusabori" is an improved Chinese method of boring which is worked by the human labour only, without any aid from a machine. The derrick for this well is 30 feet in height. The characteristic point of this well are as follows:

A bamboo pole is employed instead of the working beam, its elasticity being ultilized in drilling the well. The split bamboo jointed to required length, is also used instead of both the drilling cable and the sand line. One end of the bamboo rope is wound to the wooden wheel from 12 to 18 feet in diameter, which is turned by three workmen, and by the rotation of which the drilling tools or the sand-pump joined to the other end may be let fall down the well or raised up to the surface. On the favourable condition of the strata, the depth of this well may be carried down to 1,000 feet. Although this process needs much time for the work of boring, it is still used now, on account of the fact that its arrangement is very simple and its expense is comparatively small.

On the average, the number of workmen employed are four in the Tebori and five in the Kadzusabori, while the American rope drilling system needs at least eight workmen.

The following list shows the number of wells in Echigo in December of 1907:—

| | No. of Productive Oil-wells. | | | No. of Unfinished Oil-Wellls | | |
|---|---|---|---|---|---|---|
| Name of Oil-field. | Rope drilling. | Kadzusabori. | Teberi. | Rope drilling. | Kadzusabori. | Tebori |
| Higashiyama | 413 | 0 | 176 | 25 | 0 | 25 |
| Nishiyama | 302 | 22 | 11 | 48 | 6 | 5 |
| Niitsu (contains Kurokawa) | 471 | 207 | 15 | 53 | 77 | 0 |
| Kubiki (contains Gōtsu, Hiyama and Yoneyama) | 207 | 0 | 23 | 21 | 0 | 9 |
| Ojiya | 33 | 0 | 0 | 2 | 0 | 0 |
| | 1,429 | 229 | 225 | 149 | 83 | 39 |

The method of transporting the oil from the oil-fields to the refineries is chiefly by the pipe line, though there are numerous wells which carry the oil on the shoulders of men, by cars or by boats.

The names of the large refineries in Echigo and the quantities of crude oil to be refined per month are shown in the following list:

| Name of Oil Co's | Name of Refineries. | Average qualities of crude oil to be treated per month (in barrels) | Name of the oil-fields from which oils are to be carried. |
|---|---|---|---|
| Nippon | Kashiwazaki | 19,300 | Nishiyama |
| ,, | Naoetsu | 16,900 | Nishiyama & Kubiki |
| ,, | Niitsu | 7,400 | Niitsu |
| Hōden | Nagaoka No. 1 | 12,500 | Higashiyama |
| ,, | Kashiwazaki No. 2 | 15,900 | Nishiyama |
| ,, | Niitsu No. 3 | 9,000 | Niitsu |
| ,, | Nuttari No. 4 | 4,500 | ,, |
| ,, | Nagaoka No. 5 | 3,400 | Higashiyama |
| ,, | Sekiya | 4,500 | Niitsu |

Of the above mentioned refineries, these of Naoetsu and Kashiwazaki may be regarded as the model of oil-refineries at present.

Besides these refineries, there are many small refining companies in the following districts:—Niigata, Niitsu, Kanatsu, Nagaoka, Idzumozaki, Amaze, Takahama, Takata, Nadachi, Torigoye in Echigo province, and Sagara and Horinouchi in Tōtōmi province.

The annual production of the petroleum products in Echigo since 1904 is stated in the following list:

| Year. | Benzine in barrels. | Kerosene in barrels. | Light-oil in barrels. | Heavy-oil in barrels. | Machine-oil in barrels | Pitch in tons. |
|---|---|---|---|---|---|---|
| 1904 | 26,298 | 406,929 | 94,148 | 453,143 | 79,931 | 571 |
| 1905 | 31,888 | 419,932 | 116,582 | 469,170 | 81,337 | 695 |
| 1906 | 31,307 | 460,269 | 227,541 | 487,965 | 86,919 | 741 |
| 1907 | 34,130 | 516,157 | 254,158 | 547,805 | 91,982 | 1,365 |
| 1908 | 4,083 | 522,524 | 143,984 | 226,290 | 100,728 | 1,724 |

Since the mixture of the kerosene and the light oil is used as lamp oil, the amount produced in Echigo 1908 is estimated to 666,508 barrels by the foregoing list; and its amount corresponds to about one-third of total sum of the annual consumption of illumination oil in the Empire, which has amounted at about 2 million barrels.

## ASPHALT.

The demand for asphalt has increased lately and also its production has been considerably raised. In 1908 the output amounted to 6,246 long tons valued at £11,849 which was an increase of nearly 10 times from the figures of the preceding year both in quantity and value. But this was an insuffcient for the domestic demand and both asphalt and pitch of good quality are imported annually. In 1908 the imports amounted to 261 long tons valued at £2,291 but in 1907 they were 6,575 long tons valued at £24,852. Asphalt is for the most part imported from England. Ryūge-mura in Ugo including its environs is the only one source of the supply of asphalt. It is the only locality known to produce this substance and where many mines are operated. Asphalt occurs as a bed on Tertiary strata mixed with more or less earthy matter perhaps due to the exidation of the petroleum effused from below.

## PHOSPHATE.

The working of phosphate rock was commenced from the year 1902 which was followed by the rapid increase of production. In 1908 it amounted to 728 long tons valued at £730, but the entire production came from Minami-Torishima in the Bonin Islands and the peninsula of Noto. Such being an insignificant amount for the domestic demand the greater part was imported annually. In 1908 the import amounted to 119, 159 long tons valued at £335,095.

The outputs from several mines during 1907—1908 are given as follows:—

| Mines. | Provinces. | 1908. Long tons. | 1908. Value. | 1907. Long tons. | 1907. Value. |
|---|---|---|---|---|---|
| Minami-Torishima | Bonin Islands | 521 | £523 | 190 | £80 |
| Hannoura | Noto | 207 | £207 | 1,115 | £480 |
| Konishi-Mine | Noto | — | — | 388 | £180 |

Ores :—These ores are amorphous variety and though composed chiefly of phosphate of lime, also generally carry variable quantities of other substances such as alumina, iron or silica. No crystalline variety for practical use has as yet been discovered.

Deposite :—They occur (1) as beds in Tertiaries, (2) as concretionary nodules in Tertiaries, (3) as surface deposits composed chiefly of the excrements of birds, and (4) as irregular veins associated with manganese ore in Palaeozoics.

Distribution :—The phosphate rock deposits occur in the provinces of Noto, the Bonin Islands, Shimane, Hyūga, etc. In Noto, ores occur in the Tertiary sandstone and tuff sometimes on the andesite bed-rock. These strata extend for an extensive area and along them many mines are operated of which Han-noura is the largest producer at present. The ore is undoubtedly due to organic remain and indeed there are found many remains of shark's teeth, whale bones and many other small organisms. At Minami-Torishima in the Bonin Islands, the phosphates are mostly composed of the excrement of birds. In Shima the ore has been associated with manganese minerals imbedded in the Palaeozoic quartzite where the quantity of phosphate is very scanty. In Hyūga phosphate nodules are extensively distributed in the Tertiary strata and being of a very low-grade they have little value for practical operations. Generally speaking, in Tertiary strata phosphate rocks of low grade are frequently found in other places than the above noted. There may be opportunity, therefore, to find in future some good deposits in Tertiary strata if proper attention is given for prospecting.

# CHAPTER III.

## The Principal Mines.

### THE SADO GOLD MINE.

The Sado mine is situated at the town of Aikawa on the western coast of Sado island in the Sea of Japan, its geology consisting chiefly of strata of tuff and shale of the Tertiary age, frequently accompanied by the eruption of augite andesite. Traversing these rocks, three important veins occur, running paralled in the east and west direction. The Aoban or Dōyū vein in the most southern position, varies from 10 feet to 120 feet in width and extends for a length of 8,000 feet dipping to north at 60 degrees in the eastern part and to south in the western part. The Ōgiri or Torigoye vein in the most northern position, extends for a length of 6,300 feet, in various widths from 5 to 50 feet, and dips at the same angle as the Aoban, but in the contrary direction. Lastly the Ōdate vein in the middle position extending for a length of 1,900 feet, is 5 to 30 feet wide and dips to south at 80 degrees, and joins the Aoban vein on the eastern and western parts. They have frequently suffered from a number of faults, among which the most famous one is that has displaced the Dōyū vien some 850 feet northwestward. The minerals contained in the ore are native gold, argentite, chalcopyrite and a little galena and zincblende. Also calcite, baryte, amethyst, etc. are associated. The average contents of gold and silver in the ore are as follows :—

| | Gold. % | Silver. % |
|---|---|---|
| Rich ore | 0.04188 | 0.6152 |
| Poor ore | 0.00084 | 0.0163 |

142 144

The mine is divided into four working sections: namely the Takatō mine, the Dōyū mine, the Ōdate mine, and the Ōgiri mine. The progress of the working of each mine will be known from the following table:

| | Entrance and its height above the sea level. | Number of levels | Depth reached, measured from the entrance. | Total length of levels. |
|---|---|---|---|---|
| Takatō mine | Shaft. 389 ft. | 5 | 960 ft. | 14,570 ft. |
| Dōyū mine | Level. 716 „ | 4 | — | 10,910 „ |
| Ōdate mine | Shaft. 600 „ | 5 | 940 „ | 19,817 „ |
| Ōgiri mine, (a) Ōgiri | Level. 540 „ | 6 | 381 „ | 7,240 „ |
| „ (b) Torigoye | Level. 830 „ | 9 | 568 „ | 15,830 „ |

In each of the Takatō and Ōdate mine, there is a shaft attaining 1,000 feet in depth, provided with a winding engine and pumps. In both shafts, levels are usually opened at intervals of every 150 feet.

The main adit from the second level of the east Ōdate mine reaches the coast of Aikawa. It has totally a great length of 11,000 feet. The lower course of it for a length of some 3,600 feet was excavated about two hundred years ago, with chisels and hammers only without any use of explosives. The work was completed in thirteen years. The water below that adit is pumped up in two lifts through the Takatō and the Ōdate shafts. Six pumps are used at present, power amounting to 235 H.P. They are Knowle's, Special and Cornish.

Recently experiments in the mine proved that acetylene light is more powerful and cheaper than any other oils such as petroleum, linseed and white sesame oil, so that those lamps are being used partly.

The ore conveyed out from underground is dumped over to grizzlies spaced 45 mm. apart, it being washed with water at the same time. The oversize is broken by rock breakers and the product together with the grate undersize is classified through a trommel with 15 mm. holes into lump and fine. The fine ore is delivered to stamp mills. The lump ore is sent to picking tables, on which they are sorted into the rich and poor ore and rubbish. These ores are respectively sent to the smelting works and stamp mills and the rubbish is dumped.

Cobbing plants:—The cobbing plant of the Takatō consists of three grizzlies 3 feet × 2 feet, three Blake crushers 7 inches × 11 inches with maximum capacity of 3.5 long tons per hour, two trommels 8 feet × 2 feet 6 inches, four picking tables 22 feet 4 inches × 1 foot 7 inches. The plant of the Ōdate is made up of two grizzlies, two crushers, two trommels and four picking tables.

The poor ore is treated by battery amalgamation and cyanide process while the rich ore together with the concentrates and the cyaniding precipitates are smelted in a blast furnace.

The poor ore, if necessary, is crushed by a Blake crusher and fed by Tulloch's ore feeders to the batteries lined with amalgamated plates. The tailings, after passing the Duncan's concentrators, are led through a sluice into the cyanide plant.

The result of the amalgamation is shown below:—

| | Rate of extraction. | Contents in tailings. |
|---|---|---|
| Gold | 62.15% | 0.00034% |
| Silver | 17.53% | 0.00860% |

The amalgamation plant consists of two ore stores, four ore bins, one wooden sluice, four breakers, forty feeders, forty stamp-batteries of five stamps—each stamp weighing 970 lbs., the height of the drop 8 inches, ninety blows per minute and the screen are 32 meshes—forty apron plates (each 6 feet × 4 feet), forty shaking plates 12 feet × 4 feet and forty Duncan's concentrators (5 feet in diameter).

The cyanide plant consists of the sand and the slime cyaniding works. The tailings from the Duncan's concentrators are allowed to settle down in the settling ponds and the overflow goes to the spitzkasten. The settled sand is taken up from the ponds, heaped up to leach water out and sent by hanging rails to sand ore bins. After classifying, the coarser and finer sands are charged separately into leaching tanks and treated with cyanide solution of 0.2 per cent. strength. The residue is sluiced out into the river. The gold solution is allowed to pass into the zinc boxes to precipitate the noble metals. The precipitates are smelted with lead in a melting furnace and the product is cupelled for gold and silver bullion. The rate of the extraction from the sand is as follows:—

| | Rate of extraction. | The content of residue. |
|---|---|---|
| Gold | 68.29% | 0.000074% |
| Silver | 29.01% | 0.004710% |

The overflow from the settling ponds, before described, being mixed with lime automatically on the way, enters to a large spitzkasten. Thus the slime water is concentrated into some 11 per cent. of the original volume. The slime water is now poured into tanks, in which it is allowed to settle, and the clear water is decanted. Then the slime water is reduced in volume to 7 per cent. of the original. This concentrated pulp is put into leaching vats and the cyanide solution of 0.1 per cent. strength is added. By means of centrifugal pumps, the slime is agitated and fed with air. The clear soluton being taken out, the residue is again dropped into the lower washing tanks. The dilute cyanide solution is added, the pulp is again agitated as before and the clear solution is decanted. The settled slime is filtered by the press of Sado type. The residue is sluiced out into the river. The three clear solutions procured are sent to precipitating boxes as in the case of the sand cyaniding.

| | Rate of extraction. | Content in the residue. |
|---|---|---|
| Gold | 88.73 per cent. | 0.000094 per cent. |
| Silver | 48.24 ,, | 0.007780 ,, |

The rich ore is treated in a dry way, together with the precipitates of the cyanide processes and the concentrates from the stamp mills. They are smelted in a blast furnace with lead, using oxidized iron ore and marl as a flux. Thus gold and silver are absorbed in lead. The enriched lead is subjected to cupellation, by which gold and silver bullion is procured. The concentrates are sometimes agglomerated or roasted together with the matte. The roasted matte is then melted for plumbiferous black copper, wtih the roasted iron ore. After liquation of the lead, the black copper is melted for refined copper.

The smelting plant consists mainly of one reverberatory furnace with roasting capacity of 5 long tons precipitates per hour and one water-jacket furnace, 3 feet in diameter at the tuyeres, with the daily capacity of 15 long tons of ore. The result of the smelting is as follows:—

Rate of the extraction of crude gold and silver bullion.

| | |
|---|---|
| Rate of the extraction of crude Gold bullion | 101.00 per cent. |
| " " " " " " Silver " | 106.22 " |

For motive power the Sado mine resorts chiefly to steam for which purpose eleven boilers of various types are used. Water power can not be utilized to any extent.

For the transportation of ore and fuel, two aerial rope tramways are used, of which one is a double rope tramway, 6,432 feet long, with a capacity of 200 long tons of ore in eight hours and the other is of single system, 2,415 feet long and transports 100 long tons of ore.

The labourers employed are 1,238 persons: the miners 407, the dressing or picking men 137, the cyaniding and smelting men 131, porters both overground and underground 339, workmen both overground and underground 163 and miscellaneous workmen overground and underground 61.

The following quantities of ore and metals were produced during 1904—1908:—

| | Ore. long tons. | Gold. troy oz. | Silver. troy oz. | Copper. long tons. |
|---|---|---|---|---|
| 1904 | 55,610 | 10,100 | 100,989 | 11 |
| 1905 | 71,612 | 11,595 | 91,501 | 6 |
| 1906 | 71,123 | 12,054 | 99,615 | 14 |
| 1907 | 71,941 | 13,184 | 116,991 | 6 |
| 1908 | 81,510 | 13,740 | 113,652 | 4 |

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## THE HASAMI GOLD MINE.

The mine is situated four and a half miles south of Arita, a station on the Nagasaki line of the Kyūshū railway. In February 1906, in order to re-organize the whole plant and to make it ten times as large as the previous one, i.e. to produce and treat 400 long tons of ore per day, designs were made to enlarge the main levels and to build a new milling and cyanide plant; so that since that date the mine has been in the course of transformation. At present, the greater part of those improvements have been nearly finished, but for the sake of making such a change, the actual milling and cyanide treatments have been suspended since 1907, while the work of the mine has been confined to prospecting.

The deposits are veins filling the fissures crossing the alternate layers of sandstone and clay of the Tertiary age. The liparite appears on the sourthern part of the concessions. Seven veins can be traced out, the general strike being N 45° W and dip 70°—80° W but sometimes to E with similar dip angle. Three of those veins are worked now. The length of the main vein, traced along the outcrop, is 5,200 feet, the maximum width being 50 feet while the minimum is 6 feet, the height above the adit level being 270 feet. The main vein has a branch 800 feet long, the width at the junction being 150 feet. The length of Ichigōhi (the No. 1) vein along the strike of the outcrop is 3,000 feet, width 1—6 feet and the height 240 feet. This vein dips to E. The length of the Kōsei vein, along the strike of the outcrop is also 3,000 feet, width and height being respectively 3.5—6 feet and 400 feet. The average grade of the ores are 0.0009% Au. and 0.003% Ag.

There are two main adits of 12′ × 11′ section each and 1,300 feet total actual length in which electric locomotives run, two crosscuts of 5′ × 7′ section each on adit level and five driving courses of 5′ × 7′ section each on 100 feet level above the adits while at present a rectangular shaft of 8′ × 18′ in section is being sunk. For prospecting purposes a Temple Ingersoll electric air drill of $1\frac{3}{4}$ type and a Box electric drill are used.

As the main vein is about 50 feet wide, it was designed to cut level at every 100 feet along the hanging wall in the vein and to attack the vein by overhand stoping from the point determined on the top of the drivings at intervals of 350 feet horizontally, through the whole width of the vein, the height of one stoping face being six feet.

With regard to transportation in the underground passages, ores are sent on levels and through winzes to an underground electric double railway line on the main adit level where they are loaded in iron tubs drawn by electric locomotives. The length of the underground electric railway already laid is 1,300 feet as before mentioned and that of the overground from the adit to the top of the mills is 1,200 feet, this underground electric railway being to be prolonged to the length of 6,100 feet. There are two electric locomotives actually in use, of 25 kilowatts each, drawing 10 iron tubs having each a loading capacity of one long ton of ore. Each locomotive makes a round trip in half an hour.

The future milling and cyanide plants, are to be as follows:—

The 400 long tons of ore brought by the locomotives are first sorted by the grizzly to the size of one and a half inch. The ore passed over the grizzly is crushed by two 24″ × 22″ Blake crushers. The ore smaller than one and a half inch is fed directly to the stamp batteries. There are sixteen batteries of five stamps of 1,100 lbs. each. The copper plates 5 feet wide and 15 feet long are followed by mercury traps and then by eight classifiers of 17 feet in diameter and 4 feet in depth, by which it is separated into sand and slime. The sand separated is charged to eight cyaniding tanks of 40 feet in diameter, 50 feet in depth, 250 long tons capacity each; while the slime is sent to two classifiers of 33 feet in diameter and 10 feet in depth, in which the water is removed and a weak cyanied solution is added to the slime. Finally it is pumped up into three agitation tanks, each of 50 long tons capacity and of 20 feet in diameter and 10 feet in depth. The zinc boxes are each 24 feet long and three feet square in section. The strength of the strong solution is 0.2 per cent., that of the weak solution 0.1 per ent. and that of the solution used for that slime 0.03 per cent. All the tanks above mentioned are made of iron.

The hydro-electric power plant is now in the course of erection. The distribution of the powers of the new plant is to be as follows:—

| | | |
|---|---|---|
| Drills | 7 | H.P. |
| Shaft pumping | 10 | „ |
| Shaft winding | 15 | „ |
| Electric locomotives | 70 | „ |
| Crushers | 50 | „ |
| Stamps | 300 | „ |
| Elevators | 118 | „ |
| Aerial tramway | 25 | „ |
| Lighting | 23 | „ |
| Total | 618 | „ |

The annual production of ores and noble metals in three years ending in 1907 are:—

| | Ores. | Gold. | Silver. |
|---|---|---|---|
| 1905 | 7,709.7 tons. | 1,631.990 troy oz. | 5,101.70 troy oz. |
| 1906 | *4,1740. „ | 1,436.269 „ | 5,316.94 „ |
| 1907 | — „ | †344.147 „ | †259.75 „ |

## THE USHIO GOLD MINE.

The mine is situated in the northern part of Kagoshima Prefecture in Kyūshū, about 15 miles south-east of Kurino station.

The mine lies at the west slope of the Kirishima volcano and the principal rocks are augite andesite, propylite and Tertiary rocks. The deposits belong to fissure filling quartz veins which are classified into two groups concerning the strikes, the one being nearly EW and the other nearly NS. The champion lode is one of the former group with augite andesite as a country rock. The average width of the vein is 6 feet and it swells up to 20 feet in a chimney, but at the east part, it changes to a barren calcite vein with propylite as a country rock. The enrichment reaches to nearly 300 feet down from the adit and below this level the richness appears to decrease gradually. The average grade of the ore at present is 0.387 oz. of gold per ton.

The ore coming from the mine is crushed by Blake crushers to one inch and fed to stamp batteries. Four batteries of 850 lbs. stamps and six batteries of 500 lbs. stamps are used. By stamp amalgamation nearly 20% of gold in the ore is extracted. The pulp, after flowing over amalgameted copper plates, is dewatered and cyanided.

Electricity of 400 H.P. is purchased from a hydro-electric station about 6 miles distant. Annual productions for the last five years were as follows :—

* Being the product of mining for nine months.

† Being the product of slime cyaniding for eight months.

| Year. | Raw ore in long tons. | Gold in troy oz. | Silver in troy oz. |
|---|---|---|---|
| 1904 | 25,052.00 | 15,382.626 | 6,741.905 |
| 1905 | 24,407.54 | 16,246.086 | 6,144.750 |
| 1906 | 23,968.25 | 10,639.100 | 4,349.690 |
| 1907 | 22,995.06 | 10,043.857 | 4,319.324 |
| 1908 | 19,600.00 | 8,932.200 | 3,426.600 |

The number of the labourers at the end of 1908 was 120 for mining, 29 for dressing, 173 for milling and cyaniding, 45 for transportation, 45 for workshop and 59 for miscellaneous works; thus totally 477.

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## THE ŌKUCHI GOLD MINE.

This mine works on the continuation of the vein of the Ushio mine. There are seven levels and four winzes. The mine water is pumped up to the adit by an electric turbine pump with a capacity of 375 gallons per minute. The ores are brought up to the main level from two winzes with electric winding engines.

The dressing is very simple because gold and silver are uniformly distributed in the vein. It consists only in picking out the country rock from the ore. The richness of the dressed ore is 0 359 oz. Au and 0.177 oz Ag per long ton.

Stamp amalgamation and cyaniding are used. The ore carried out from the mine is sized by a 1½ inch grizzly and the oversizes are crushed by Brake breakers. The battery is of a Californian types using 30 mesh screen. The pulp which passes over apron plates is introduced into settling tanks and classified into sand and slime; the latter is dried by heat of the sun and passed through a disintegrator. The fine dust produced is mixed with sand and then subjected to the cyanide process. There are two kinds of cyanide solution, the strong solution contains 0.3% KCN and the weak one 0.12%.

The leaching operation requires about 5 days. The dissolved solution is led into zinc boxes and the precipitates are collected on every tenth day.

The extraction percentage of gold is 85 and that of silver is 70 of the original ore content.

The annual production for the last five years was as follows:—

| Year. | Raw ore in long tons. | Gold in troy oz. | Silver in troy oz. |
|---|---|---|---|
| 1904 | 11,421.5 | 4,712.336 | 2,814.066 |
| 1905 | 16,134.2 | 4,956.866 | 2,280.185 |
| 1906 | 19,885.9 | 6,813.208 | 2,717.195 |
| 1907 | 23,739.1 | 5,962.313 | 2,403.315 |
| 1908 | 22,419.2 | 4,766 800 | 2,115 200 |

Number of labourers:—

| | |
|---|---|
| For mining | 108 |
| For smelting | 234 |
| For workshop | 20 |
| For dressing | 12 |
| For transportation | 30 |
| For miscellaneous | 20 |
| Total | 424 |

As already described, to dry the slime by the heat of the sun is a very primitive method which is often made impossible by rain, hence it is designed to replace it by the following method as future improvement. The slime is charged with cyanide solution into tanks which provide stirrers at the bottom to stir the charge so as to dissolve the gold and silver rapidly and uniformly, then it is filtered by a filter press to get the gold and silver solution.

The tailings from the present method contain from 0.0001% to 0.00015% Au; as it is too rich to be sent to the dumps it is designed to annex a certain gold saving appliance.

## THE YAMAGANO GOLD MINE.

Tha mine is situated seven and a half miles west of Yokokawa, a station on the Kagoshima line, and embraces the two mines of Yamagano and Nagano.

The deposits are fissure veins in the Tertiary volcanic region, the rocks being augite andesite, tuff, volcanic agglomerate and Tertiary shale. There are forty veins, having a general strike EW and dipping 40°—80° to N or freqnently S; in which Takatsuka vein 6—30 feet thick and 4,000 feet long in the Yamagano mine and the Sarashi vein 6—36 feet thick 5,000 feet long in the Nagano mine are principally worked.

The main adits actually in use are the Hiire adit 2,000 feet long in Yamagano mine and Gomame adit 5,000 feet long in the Nagano mine. Besides the above there are two cross-cuts in Nagano, one being Sanbandaki cross-cut 1,500 feet long. The heights of Gomame and Hiire adit above the Sanbandaki are respectively 100 feet and 480 feet.

The excavation of the Sanbandaki cross-cut is facilitated by using two Water Leyner rock drills and within a short time in the future Sergeant rock drills will also be used in Kotaka cross-cut. In the Gomame adit one ton steel tubs drawn by horses on 25 lbs. rails are used, while in other mines half a ton wooden tubs are in use on 9—12 lbs. rails, the gauge being 20 inches in both cases. There is one dressing house in Nagano in which some inferior ores are crushed with a No. 5 Blake crusher, sized with a trommel having 0.05 feet dia. punched holes and subjected to hand picking on a picking belt.

In the Yamagano mill there are twenty stamps of 900 lbs. weight each, actually stamping 660 long tons of ore monthly. The stamped ore running over 4 sets of fixed and shaking copper plates flows into pointed boxes, in which it is separated into sand and slime. The slime is sent directly to cyaniding vats while the sand is sorted again on three Wilfley tables, into heavy amalgam, sulphides, light sand and slime. The former two are subjected to pan amalgamation, while the latter two are sent to the cyanide plant.

In the Yamagano cyanide plant, sand and slime, with one per cent. of lime added, being placed in a wooden cyaniding tank of 20 feet in diameter and 4.5 feet in depth are subjected to the common cyaniding process.

In the Sanbandaki mill, there are one roll jaw crusher made by the Sturtevant Co., America, crushing 2—2.5 long tons of ore per hour and eighty stamps of 900 lbs. weight each, forming sixteen batteries, actually stamping 2,200 long tons of ore monthly. The stamped ore running over sixteen pairs of fixed and shaking copper plates flows into four pointed boxes in which it is classified to sand and slime. Both sand and slime, thus separated, are treated separately by eleven Wilfley tables; and heavy amalgam, sulphides, light sand and slime are obtained. Both headings thus obtained are subjected to pan amalgamation, while the tailings are classified again in pointed boxes into sand and slime which are treated separately.

In the Sanbandaki sand cyanding plant, all the sands are gathered and charged into four separating tanks, made of iron, of 30 feet in diameter, 6 feet in depth, 110 long tons capacity each, in which the slime still remaining in the sand is drawn out; the slime thus separated being sent to the slime treatment, while the remaining sand only is subjected to sand treatment in this plant. The sand with a strong solution of 0.2% KCN and 0.5% lime added is placed in leaching vats, made of iron, of 30 feet in diameter, 7 feet in depth and 100 long tons capacity each and is subjected to common cyaniding.

In the Sanbandaki slime cyaniding plant, the slime with 0.5-0.6% lime added, flows into two conical settlers of 20 feet diameter each, 15 and 20 feet depth respectively. The settled slime with a weak solution of 0.13% KCN added, is drained into 2 agitators and then pumped into a monlegn 6 feet in diameter and 20 feet long, from which it is forced into a filter press with a pressure varying from 2 lbs. to 80 lbs. per square inch. In the filter press 4 long tons of slime is filtered in from 2 to 3 hours. The filtrate is treated according to the common cyanide process.

There is water power capable of generating 800 kilowatts of electricity and at present by using one dynamo 400 kilowatts is generated.

The number of labourers employed at the end of December 1908 is 2,080.

The annual production of ore and noble metals for the five years ending in 1908 was:—

| | Ore. long tons. | Gold. troy ounces. | Silver. troy ounces. |
|---|---|---|---|
| 1904 | 37,000 | 9,055.787 | 10,269 0 |
| 1905 | 43,370 | 11,910 792 | 10,631.9 |
| 1906 | 41,771 | 11,009.783 | 10,278.2 |
| 1907 | 33,474 | 8,575.330 | 7,693.2 |
| 1908 | 62,820 | 12,167.500 | 26,735.0 |

## THE KINKWASEKI GOLD MINE.

There is a gold field about ten miles east of the harbour of Kilung at the north-east corner of Formosa, which produced 30% of the total production of gold in Japan during 1908. The district is mountainous and faces the East China Sea to the north; the mine occupied the north-east part of the district and is owned by Mr. Tanaka. It was discovered in 1890 and operated by the Chinese or their Government up to 1895, when the present owner took possession of it. The geology of the region is composed of dacite, Tertiary sandstone and clayey shale, which strikes N 30°—40° E and dips towards SE at an angle of 45° while three coal seams of 1 to 3 feet thickness were intercalated in them. Six groups of gold-bearing lodes occur in or between the dacite and the Tertiary.

| Group of veins. | No. of veins. | Strike. | Dip. | Width. | Approximate known length | Chief gangues or associates. |
|---|---|---|---|---|---|---|
| I | 2 Quartz veins. | NS | E 80° | 3′-10′ | 2000′ | Energite brown or bluish clayey matter, Baryte. |
| II | 4 Branch vains. | EW | N 80° | 1′-5′ | 100′-200′ | " |
| III | 2 Clay veins. | NS | E 80° | 3′-5′ | 2000′ | Red clayey matter, pyrite. |
| IV | 2 Quartz veins. | N 26°W | W 62° | 5′-70′ | 1500′ | Gray clayey matter, calcite, baryte. |

| | | | | | | |
|---|---|---|---|---|---|---|
| V | 1 Energite veins. | Pockets | — | 4′-60′ | ? | Energite. |
| VI | 1 Quartz veins. | S 70°E | E 70° | 3′-7′ | 1000 | White clayey matter. |

Besides the above mentioned associates, pyrite, chalcopyrite, bornite, zincblende, galena and cinnabar occur. The gold ore contains 0.075—0.00155% Au and the copper ore has 16—1.2% Cu, 0.0023—0.0013% Au and 0.012—0.008% Ag. The veins are approached from the outcrops or by cross-cuts of 6′ by 10′—5′ by 8′ cross section. The total length of the main levels is 59,678 feet, its greatest difference of heights being 1,350 feet. Over or underhand stoping is employed as the method of mining in which the heights of each stope is 6—7 feet, the distance 25—30 feet and the width 3 feet at minimum. The vein wider than 20 feet is worked as two or more separate veins. The lowest level being 700—800 feet above the sea level, the water is drained through the levels. As the methods of extracting gold the stamp amalgamation and cyaniding are employed, while the agitation process is applied for the slime. The brief sketch of the plant is as follows:—

One roll jaw crusher, five Blake crushers, two batteries of 850 lbs. stamps, twelve batteries of 550 lbs. stamps, three 3′ dia. Huntington mills, ten 12′ × 5.5′ shaking copper plates, five Wilfley tables, ten hydraulic classifiers, eight 23′ dia. sand lixiviation vats, four 10.5′ × 8.3′ × 8.7′ deep pulp agitation vats, six pumps, etc. There are two rectangular and one round smelting furnace for the treatment of concentrates and copper ore. As the sources of power, there are two Cornish, one multitubular boilers, two 30 H.P. steam engine, two 75 H.P. Pelton, one 250 H.P. Pelton and one 200 H.P. dynamo. 556 persons were employed at the end of 1908; the productions for the last five years were:—

| Year. | Ore treated. | | Products. Gold. | | Silver. | | Copper. | |
|---|---|---|---|---|---|---|---|---|
| 1904 | — | long tons. | 20,571 | troy oz. | 4,024 | troy oz. | — | long tons. |
| 1905 | 19,375 | ,, | 28,585 | ,, | 6,081 | ,, | — | ,, |
| 1906 | 25,057 | ,, | 16,707 | ,, | 4,229 | ,, | — | ,, |
| 1907 | 25,721 | ,, | 14,555 | ,, | 8,428 | ,, | 46 | ,, |
| 1908 | 31,054 | ,, | 33,353 | ,, | 25,558 | ,, | 319 | ,, |

## THE BOTANKŌ GOLD MINE.

The mine is located at the southern part of the gold field at the narth-east corner of Formosa and is worked by Mr. Mimura. It was started three years later than the Kinkwaseki mine. The geology is the same as that of the Kinkwaseki mine. The two groups of N 20° W and EW veins occur in the volcanic and the Tertiary. The former group consists of more than ten veins and dips 80° to the west, the width being 5′-40′ and the length being 1000—2000 feet. They are associated chiefly with brown clayey-matter and baryte. The latter group dips 80° to the south and is 1′-2′ broad, the length being 500—1500 feet. The ore contains 0.007—0.002% Au. The method of mining is similar to that in the Kinkwaseki. But owing to a great pressure in the excavated part of the veins, the main levels are driven in the country rock 6′-10′ apart from the veins. Water-Leyner rock drill is used in dead works. The total length of the main levels is 7,867 feet, the depth of them being 800 feet. The metallurgical plant consists of one roll jaw crusher, six Blake crushers, two batteries of 100 lbs. stamps, four batteries of 600 lbs. stamps, two batteries of 200 lbs. stamps, eight Huntington mills, seven Overstrom tables, five Wilfley tables, six 18′ dia. sand leaching vats, eight 30′ dia. sand lixivation vats, five 10′ dia. agitation vats, four pumps, six 5′ dia. settlers, etc. There are one Cornish, one Lancashire boiler, one 300 H.P. and one 86 H.P. steam engine, one 350 H.P. Pelton wheel and one 260 H.P. generator. 343 persons were working in this mine at the end of 1908. The productions, etc. for the last five years were as follows:—

| Year. | Ore mined. long tons. | Gold. troy oz. | Silver. troy oz. |
|---|---|---|---|
| 1904 | — | 16,228 | 8,221 |
| 1905 | 13,000 | 17,336 | 10,601 |
| 1906 | 23,051 | 15,352 | 2,289 |
| 1907 | 36,340 | 13,300 | 3,419 |
| 1908 | 23,810 | 9,193 | 3,873 |

## THE DZUIHŌ GOLD MINE.

The mine is operated by Mr. Fujita and is situated at the west of the gold field at the north-east corner of Formosa. Three clay veins accompanying black clay and pyrite occur in Tertiary, with a length of about 3000 feet. They strike N 30° E, dip W 65°, the average width being 3 feet, 2 feet and 2 feet respectively. Three impregnation veins exist in dacite, striking S 35° W, dipping W 65°. It is about 1000′ long and 1.2 feet, 0.5 feet, 2.0 feet wide respectively on an average. The crude ore consists of 0.001% Au, 0.0014% Ag, 0.04% Cu, 4.16% $H_2O$, 4.54% Fe, 12.51% $Al_2O_3$, 0.11% $MnO_2$, 0.23% CaO, 0.43% MgO, 2.11% KO, 0.27% NaO, 70.27% $SiO_2$, 4.45% S, and 0.14% P. The main levels are 45,290 feet long totally and placed in about 1000 feet height. The method of the extraction of the gold is similar to the above two mines, but in the treatment of the slime the filter press is used instead of decantation process. The chief machines are five Blake crushers, three 6′ dia. Huntington mills, six 5′ dia. Huntington mills, two 3′ dia. Huntington mills, five Wilfley tables, eight hydraulic classifiers, four 12′ by 8′ and 8′ deep agitation vats, two 15′ dia. and 15′ deep agitation vats, six pumps, two Dehne filter presses. 259 labourers were employed at the end of 1908. There are two water tubular, one Lancashire and one Cornish boiler; one 75 H.P. Tandem compound engine, one 150 H.P. Russel's engine; one 85 H.P. Pelton, one 30 H.P. Pelton; one 32 H.P. dynamo.

| | The mined ore long tons. | Gold troy oz. | Silver troy oz. |
|---|---|---|---|
| 1904 | — | 10,765 | 1,256 |
| 1905 | 32,518 | 10,278 | 1,187 |
| 1906 | 35,796 | 11,737 | 7,025 |
| 1907 | 40,517 | 10,636 | 5,597 |
| 1608 | 36,021 | 8,962 | 3,984 |

## THE TSUBAKI SILVER MINE.

In the earlier workings of the Tsubaki mine, only the rich parts were sought for and subject to the Kiss or Augustin process; the latter process has prevailed over the north-east of our country. Tsubaki was not regarded as an important mine up to the date of the possession by Mr. K. Takeda.

The mine is situated on the coast of the Sea of Japan and thirteen miles north of the harbour Noshiro where the railway touches. The adit mouth is only twenty feet above the sea level and within but a few hundred feet from the shore. The deposits consist of three masses i.e. Homma, Sōzen and Higashimuki; the first mass maesures 400 feet by 600 feet, the second 300 feet by 400 feet and the third 200 feet by 250 feet; they are divided by barren stripes of Tertiary shale which is penetrated by dykes of augite andesite. It is now worked to the depth of 220 feet from the adit mouth, while the dimension of the deposit still remaining constant. The ore is made up from argentiferous galena, zincblende, iron pyrites with much silicified country rock, baryte and sometimes witherite. The silver content of the average ore is 0.08—0.15% Ag.

The average analysis of all ores except that of Higashimuki is as follows:—

| | Cu. | Pb. | Zn. | Fe. | $BaSO_4$. | $BaCO_3$. | S. | $Al_2O_3$. | $SiO_2$. | CaO. | MgO. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sōzen | tr. | 0.05 | 1.03 | 2.11 | 8.50 | 1.95 | 1.95 | 13.61 | 70.42 | 0.22 | .06 | 99.74 |
| Homma | tr. | 0.32 | 2.03 | 2.18 | 12.17 | 1.22 | 1.22 | 15.17 | 68.50 | 0.35 | .04 | 99.88 |

The ore hoisted up the shafts is sized by the grizzlies and trommels. The ore larger than 1″ is subjected to hand picking, while one of 1″—1/8″ size is treated by eight Harz jiggers. Fines smaller than 1/8″ are directly sent to the smelting with the heading from the jiggers. The middlings are returned to the jiggers after being crushed with Blake crushers or with Sturtevant rolls. The tailings are sent to the underground for packing material. One Hancock jigger has been in use since June in 1909. There are three motors of total 80 H.P. for dressing operations.

Smelting is rather difficult on account of its highly silicious and barytic nature, also from the fact that it is containing alumina in somewhat large quantities; so that pyrites, raw and calcined, and limestone are used.

All the fines are made into briquets which are charged into blast furnaces. There are two water jacketed furnaces of Takeda's patent. The first is employed for pyrite or reduction smelting and provided with forty-two tuyeres of 6 inches diameter. The second is chiefly for pyrite smelting and has twelve tuyeres. It is intended to erect one more furnace which will be a total jacketed one.

There are two No. 9, two No. 6, one No. 3 of Root's blowers and one No. 6 Baker's blower.

The chief source of the power is derived from water. The generating station is situated about 1.5 miles north of the mine where one 300 k.w. three phase genetor driven directly by 500 H.P. McCormick turbine and one 120 k.w. dynamo driven by 200 H.P. McCormick turbine are provided. Besides these, there is one generating station at the mine and there are also four steam engines of the non-condensing single cylinder type for reserve, amounting to 265 H.P. in all.

As to overground traffic, the longest aerial tramway in this country was erected in 1907 between Tsubaki and the harbour of Noshino, which is 11 miles distant and nearly horizontal. Its capacity is 160 tons per day and it is driven by 75 H.P. motor. This is chiefly for use in stormy weather, as otherwise ships of over a thousand tons are able to lay at anchor within half a mile off the coast and vessels smaller than 20 tons can be reached from the shore. For workshops 100 H.P. is used. The numbers of workmen were 578 at 1908.

The products were as follows:—

| | The mined ore, long tons. | Silver production troy oz |
|---|---|---|
| 1904 | 3,371 | 90,528 |
| 1905 | 6,152 | 112,301 |
| 1906 | 11,945 | 126,311 |
| 1907 | 41,091 | 444,112 |
| 1908 | 69,170 | 1,244,572 |

## THE INNAI SILVER MINE.

The mine is one of the oldest mines in Japan and is located 3.8 miles west of Innai station on the Ōu railway. The district is composed of Tertiaries, andesite and tuff, the ravines being covered by Quaternary. There are two principal lodes called Honpi and Shihyakumai with several smaller veins, the strikes and dips of which are very irregular. They have a banded structure, the outermost band being composed of rhodochrosite, the next of ores containing gold, silver and the innermost is made of quartz. Besides the common silver ores, chalcopyrite, galena, zincblende, pyrite and cinnabar occur in them. The ore contains 0.001% gold and 0.15% silver.

The mine is developed by shafts, one of which is equipped with head-gear of iron construction and is 1,370 feet deep. Overhand-stoping is applied for the winning of the ore; the height of each stope is 7 feet, the minimum width being 2 feet. The dressing is mainly by hand, the ore is at first crushed to 2″ and classified into three kinds according to the size, the larger pieces being subjected to hand dressing and the smallest to mechinical dressing. The plant is made up from two screens, fifty stamps, six trommels, sixteen Wilfley tables, five picking tables, three blanket sluices and one water balance. The metallurgical plant consists of two round blast furnaces, four Mabuki hearths, two blowers, twenty stamps for briquets, six drying furnaces for briquets and one water balance. Formerly the wet process was used, but now the ore is smelted with copper ore from other mines. The power plant is made up from two Pelton wheels of 500 H.P. with corresponding generators and eleven motors of 436 H.P., of which 198 H.P. are used in the mining, 150 H.P. for the dressing, 65 H.P. for the metallurgy and 50 H.P. for the workshop. 266 miners and 81 overground workmen were employed there at the end of 1908. The production for these five years was as follows:—

| Year. | Silver ore mined. long tons. | Copper ore from other mines. long tons. | Gold. troy oz. | Silver. troy oz. | Copper. long tons. |
|---|---|---|---|---|---|
| 1904 | 12,090 | — | 1,548 | 261,563 | — |
| 1905 | 20,590 | — | 1,638 | 164,896 | — |
| 1906 | 29,508 | 3,486 | 2,224 | 189,118 | 113.2 |
| 1907 | 33,017 | 4,909 | 1,600 | 145,512 | 260.0 |
| 1908 | 11,703 | 2,433 | 968 | 94,758 | 153.0 |

## THE KAMIOKA SILVER AND LEAD MINES.

The Kamioka mine, thirty miles distant south of Toyama, is situated in the mountainous region in the Hida plateau, near by the Takahara river.

The geology of the Kamioka mines consists of the gneiss series of the Archean age. The chief rock is gneiss which is frequently intercalated with limestone and quartzite, being intruded rarely by dykes of quartz-porphyry and porphyrite. The ore deposits occur in the forms of irregular elliptical column or masses which are caused by the metasomatic replacements of the lenses of limestone. The ore bodies existing in such irregular masses have no distinct boundaries with the country rock; and their worked portions vary from few feet to 10 feet and often up to several hundred feet in width, and also frequently attain similar vertical heights.

The ore consists of argentiferous galena and zincblende, associated with chalcopyrite, malahyte, cerussite, iron-pyrite and pyrrhotite, and the non-metallic minerals are quartz, calcite and contact minerals such as actinolite, garnet, etc. The average contents of the ores are as follows :—

| Name of ore. | Silver % | Lead % | Zinc % |
|---|---|---|---|
| Tochibora lead ore | 0.012 | 2.5 | 10.0 |
| „ zinc „ | 0.009 | 1.3 | 16.0 |
| Urushiyama lead ore | 0.007 | 14.0 | 14.0 |
| Jabara zinc ore | a very little. | a little. | 25.0 |
| Mochigakabe ore | 0.012 | 8.5 | 11.0 |
| Ikenoyama ore | 0.005 | 6.5 | 10.0 |
| Tentōhira ore | 0.025 | 9.0 | a little. |
| Atotsu ore | 0.010 | 10.0 | 15.0 |

The deposits are worked by overhand stoping or a combination of overhand stoping and the long wall systems, according to they are regular or irregular. Three adits are being now driven, which have been more or less advanced already. One shaft is also being sunk.

There are three dressing works. The products of the dressing are lead concentrates, the content of which averages about 60 per cent. and zinc concentrates, the content of which averages about 48 per cent.

For the Jabara zinc ore containing much pyrrhotite, magnetic separation has been recently adopted. The separation is operated by three magnetic separators. The magnets electrified by the current of ten amperes and one hundred volts from a dynamo.

The flotation process has been recently adopted to the middlings (25—30 per cent. zinc), the products being 55 per cent. zinc concentrates. For this process, water acidulated with a little sulphuric acid is used. Sometimes, oil is used according to the character of the ores.

The lead ore is roasted in reverberatory furnaces or in lime-roasting pots, and smelted with fluxes in a shaft furnace. The products are lead, matte and slag. The lead is subjected to liquation process. The copper matte is crushed and subjected to lime-roasting. It is then smelted for a second matte in a blast furnace, and melted in a Mabuki hearth with lead to get plumbiferous copper. It is then charged in a liquation hearth. The lead from the softing furnace is treated in Park's pans. The zinc scum from the pans is treated in the Morgan distillation crucible, while the rich lead is subjected to the English cupellation. The desilverized lead is charged into a refining furnace to remove the remaining zinc.

The installatian of the metallurgical works: three roasting reverberatory furnaces—two 16.4′ × 63.3′, one 15.2′ × 45.4′; three roasting pots, 7′ diam. × 3.5′; three round water jacket furnaces—one, 3′ diam. × 18′, two 3.5′ diam. × 18′—one rectangular water jacket furnace 3′ × 5′ × 18′; one liquation furnace 3′ × 5.9′; one softing furnace 5′ × 9′ × 1.45′; two Park's pans, 5′ diam. × 2.5′ with one scum separation kettle, 2′ diam. × 1.5′; one lead refining furnace 5′ × 9′ × 1.45′; one zinc distillating furnace; one English cupellation furnace, 3.3′ short axis × 4.7′ long axis; one silver refining furnace; two Mabuki hearths, three liquation hearths and five No. 5 Root's blowers.

There are twenty one lines of aerial rope-tramways, just 50,000 feet long in all, and also a total length of 16,050 feet of several railways overground.

The floation process and the magnetic separation will be largely used in future. Not only for the ores but also the copper matte will be roasted in pots.

Twenty Pelton water wheels are used for direct driving of machines, of which two are used to operate dynamos.

The labourers employed are 2,251 persons: mining 893, transporting 221, wire rope 84, dressing 32, smelting 51, assaying 26, workshop 107, store keeping 29, and other services 912.

Products.

| | Ore. long tons. | Gold. trog oz. | Silver. trog oz. | Copper. long tons. | Zinc concentrate. long tons. |
|---|---|---|---|---|---|
| 1904 | 13,766 | — | 146,720 | 70 | — |
| 1905 | 41,384 | — | 135,037 | 82 | — |
| 1906 | 54,937 | — | 152,040 | 75 | 1,739 |
| 1907 | 63,246 | — | 161,109 | 36 | 5,688 |
| 1908 | 85,300 | 246.4 | 169,527 | 39 | 8,676 |

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## THE IKUNO SILVER AND COPPER MINE.

This is one of the oldest and most famous mines in our country. The mine consists of the following concessions:—

| Name of Concessions | Ores, worked for. |
|---|---|
| Tasei | Gold and silver |
| Kanagase | Copper, silver, gold and lead |
| Wakabayashi | ,, |
| Mikobata | Gold and silver |
| Akenobe | Copper and silver |
| Nakase | Gold and silver |
| Miyagaki | ,, |
| Tataragi | ,, |
| Torino-oku | ,, |
| Odate | ,, |
| Kanayama | Copper |

The smelting plant lies within half a mile of Ikuno station on the Bantan line, a branch of the Sanyō Railway. It is situated near the Tasei mine about 1,000 feet above the sea level.

Ore deposits:—

Tasei:—The deposit is auriferous and argentiferous quartz veins in granular andesite and Tertiary tuff. The main lode called

Honmpi strikes EW, its length is about 2,600 feet, the width varying from 3 to 10 feet. A lode named Okuhi runs in the same direction for a length of about 4,000 feet and its width is very irregular, the widest part being 40 feet. Another vein called Senga is from 1 foot to 4 feet wide and its ascertained length is 860 feet. There is also one lode which is being prospected now. It branches out south-westward from Senga vein and its ascertained length is 620 feet from the branching point. It varies in width from 1 foot to 5 feet, yet the widest part reaches to a width of 20 feet. The ore contains .0093% Au and 01% Ag.

Kanagase :—There are gold-silver veins and silver-copper veins in liparite in the Tertiary tuff and shale. Several dykes of basalt and andesite penetrate the liparite after the formation of the veins. The main copper vein reaches to 10,000 feet in length. There are six bonanzas which continue vertically for a long distance and are only from 300 to 800 feet in the strike. The silver bearing veins are 2,000 feet long, their width being from 3 feet to 9 feet, in which three bananzas, each 100 feet long have occurred. The ore is a compact silicious one, containing chalcopyrite, galena and iron pyrite in banded struçture; sometimes it contains calcite. The silver ore contains 0.02% silver and the copper ore 0.01% silver and 2% copper.

Wakabayashi :—The vein in this part is actually the southern end of the copper lode in Kanagase, from which it is separated by 1,000 feet displacement. The width varies from 3 feet to more than 10 feet. The ore is the same as the copper ore of Kanagase and contains 2% Cu and 0.1% Ag.

Mikobata :—There are two chief veins. The geology is amphibolite through which many dykes of liparite and andesite occur. The one is almost worked out and the other was opened a few years ago but did not prove to be prosperous. The ore from this part contains 0.0001% gold and 0.01% silver.

Akenobe :—Numerous argentiferous copper veins occur in the palaeozoic slate, among which nine lodes may be counted. The average tenor of the ore is 2% copper and 0.02% silver.

Ōdate :—There are gold and silver veins in the Mesozoic shale. Liparite and andesite dykes penetrate the veins and shale like Mikobata, About 0.0002% gold and 0.02% silver is contained in the mined ore.

Mining:—Here we shall give chiefly descriptions about Kanagase and Tasei, as they are both typical ones. The deposits are approached by cross cuts. Mainly overhand or sometimes underhand stoping is applied, its breast and sole commonly being 6 feet high and 30 feet long respectively.

The Kanagase mine is worked separately for copper and for silver veins. There is one blind shaft respectively for silver and copper veins. Both are 14 feet by 6 feet in section and are equipped with 30 horse power hoisting engines. The shaft of the copper veins reached 660 feet deep below the main adit level; from it seven levels are driven along the vein. In a horizon 250 feet above the main level of Kanagase, the deepest level of the Wakabayashi runs, the latter lying about 500 feet below the outcrops of the copper veins. A connecting level of both mines is driven along a large fault at the south end of Kanagase and after its continuation the ore from Wakabayashi will be brought to Kanagase, for this purpose a dressing house has just been finished at the adit mouth of Kanagase. The shaft of silver veins is 380 feet deep, at this depth the 3rd level is driven which is 1,400 feet long in the southern direction and 200 feet long to the north. The outcrop of the silver veins is discovered about 450 feet above the adit level of the Kanagase. There are two 30 H.P. Worthington triplex pumps at the 3rd copper level and the 2nd silver level, and 20 H.P. pumps of the same type at the seventh level of the copper veins; there is also a 20 H.P. Knowles' duplex sinking pump. The water above the fifth level of the copper part will be drained naturally, after the connection of this mine with Tasei in the near future.

In the Tasei mine there are seven levels in 725 feet difference in height, the height of the outcrop above the first level being 120 feet. An inclined shaft with 65° slope and 22 feet by 8 feet in the section is sunk from the surface to the sixth level, but only from the third to the sixth level is being used for winding. A Lidgerwood double drum hoisting engine of 35 H.P. is acting for the purpose. The connection between the Tasei and the Kanagase will be completed in March of 1910. In the Tasei mine, two Jager rock drills are moved by 20 H.P. Ingersall's double cylinder compressor. In the near future a vertical blind shaft will be sunk at the meeting part of Honmpi and Senga. As to drainage there is a 30 HP.. Worthington triplex plunger pump at the lowest level, from whence the water is pumped up to the sixth level where it is drained with the water from the upper part through a drainage level 5,200 feet long which conducts it to the other side of the mountain.

Dressing:—There is a rock-house for each mine in which the ores mined are subjected mainly to hand dressing, the middlings of which are conveyed to a central machine dressing plant. But there is nothing of particular interest except the existence of one 25 feet Hancock jigger at Kanagase.

The Mikobata dressing mill is being gradually moved to Akenobe which will be developed in the near future. Thus a mechanical dressing plant will be crected at Akenobe mine, the power being taken from the water sources. For the transportation of Mikobata ore to this place one 7.3 miles long aerial tramway will be built between both mines over a mountain. Mechanical dressing is performed in three separate devisions at the central plant.

In the noble ore dressing mill, the middle class noble ores from the rock houses of Tasei, Mikobata, and Kanagase are to be treated. They are composed of two $11'' \times 10.5''$ Breur's Sectrator breakers, two $9'' \times 7''$ Dodge crushers, five series of $5'$ dia. Huntington mills amalgamated copper plates, Wilfley, Pinder and Frue vanner concentrators. The Pinder concentrator was first used here in our country.

The Copper ore dressing mill stands just east of the noble ore dressing house, having a hauling incline between them. Copper ore middlings from the rock houses and sometimes silver ore middlings which have scarcely any gold are treated here. It is composed of Blake No. 1 breaker, trommels, round picking table, five coarse jiggers, 620 mm. dia. Krom's roll, pointed boxes, six bed-jiggers, Linkenbach and Burgy buddles, Cammett's table. The tailings smaller than 3 mm. are stored to be treated by the Elmore flotation process in future or are sometimes sold to other smelters in the Inland Sea as a silicious flux. All these machines and those of the tailing dressing are moved by 100 H.P. Girard vertical turbines.

The tailing of the coarse jigger above mentioned is to be treated in tailing dressing mill; it consists of three 5 feet dia. Huntington mills, pointed boxes, one coares jigger, five fine jiggers and three Cammett's tables.

Metallurgy:—This consists of two processes i.e. the smelting and the Kiss process. The former plant is situated south of the copper ore dressing mill in the cascade system. The latter plant stands in the west of the noble ore dressing plant. Tasei and Kanagase silver ore richer than 0.001% gold and 0.037% silver and a part of silicious copper ore in lump form from hand picking are smelted in a blast furnace with cupriferous pyrite from Kanayama, a branch mine, the matte from this smelting is to be concentrated in another smelting. The following eight kinds of ore are solidified into lumps by pot-roasting and are then fed into the second smelting charge :—

Kanagase and Wakabayashi silver ore richer than 0.1% silver; lump and small copper ores from Kanagase, Wakabayashi, Akenobe rock-houses which contain more than 4.5% copper; fine silver ore from the noble ore dressing; fine copper ore from copper ore dressing, and precipitate from Kiss process. The pot-roasting has just been started in actual working. There are two pots, one is 5 feet in diameter, 4 feet in depth and of 2.2 tons copacity and the other has 5.5 feet diameter, 4.5 feet depth and 3 tons capacity; in both of them 15 tons of charge are treated per day on the average. In the charge 8% limestone is mixed and the time of one operation is from 5 to 6 hours, but this duration may be shortened on securing more skill in working. Fines in the product are about one-third of the lump, which will be also lessened in future as well as the cost of the treatment.

The pulp settled in setting ponds for dressing, which has more than 0.012% Ag and 3% Cu, is made into briquet by wooden stamps and fed in the second smelting after being dried in drying furnoces; the richest noble ore from Tasei and Akebone, silver ore and copper ore from Kanagase and Wakabayashi are also treated in the second smelting. Formerly the richest noble ore was smelted with plumbiferous material into rich lead which was cupelled in an English cupellation furnace; but it was rejected as it is affirmed that the loss of silver and gold in Mabuki process is not so great as it was formely considered to be. There are three blast furnaces whose specifications are as follows :—

| Type. | Area at tuyere level. | Tuyeres. |
|---|---|---|
| Partial water jacketed furnace | 3.3′ × 10′ | 6″ × 12 |
| Total ,, ,, ,, | 4.5′ | 4″ × 8 |
| ,, ,, ,, ,, | 3.1′ | 3.5″ × 6 |

Three Root's No. 4 blowers are worked by 60 H.P. motor of the General Electric Company, one Baker No. 4½ one is reserved in case when the other needs repairing; these blowers are for all smelting furnaces and seven Mubaki hearths. The present capacity of the smelting plant is rather small, so that they are going to erect one more 3.3′ × 7′ partial water jacket furnace and with it one Root's No. 5 blower and also the Mubaki hearth of a corresponding capacity are to be increased. They are going to throw away the waste slag by granulation. The refining work becomes now simple as cupellation and liquation are abandoned. It is done only by the Mabuki hearth, a very simple and cheap method. There are seven of them here which have a similar construction to the one used in the Osaruzawa mine. The blister copper contains 0.02% Au, 0.61% Ag and 97.41% Cu and was sent to Osaka refinery of the same company to be electro-refined. The sources of power are partly supplied from the Hase electric power station, which will be described hereafter, and partly from Pelton wheel (30 H.P. 4 feet dia.). There are also 45 H.P. Lancashire boilers and 40 H.P. steam engine for spare.

The slimes from the noble ore dressing are treated in the wet process which is done by two drying reverberatories, an edge mill, three 3′ × 11′ hand reverberatories, thirteen 32 ton lixiviation vats, eight noble solution vats, eight precipitation vats, two pulsometers, a Wegelin filter press and two 45 H.P. Lancashire boilers. The recent progress in smelting and dressing makes the tenor of the stuff to be treated in Kiss process so poor that in the near future cyaniding will be practiced, the object being chiefly for the extraction of gold. For Tasei ore the direct cyanide process will be applied and for Mikobata and Akenobe ore chloridizing roasting and then cyanidation will be done. The pulp will be treated by the agitation and decantation process.

Electricity Generation:—The generating station were erected in September 1902 at Hase 4.5 miles distant from the smelting works and on the west bank of the Ichikawa which runs along the smeltery. The water wheel is one 250 H.P. Francis horizontal turbine. There are two of them to which two 150 k.w. dynamos (3,450 volt) are directly connected.

There are nine motors of a total 295 H.P. moved by this source of power. We shall stop the description of this mine writing down the production during the last five years and the number of labourers at the end of 1908:

| Year | The ore mined. (long tons) | Gold production from ore. (troy oz.) | Silver production from ore. (troy oz.) | Copper production. (long tons) |
|---|---|---|---|---|
| 1904 | 33,396 | 7,070 | 231,702 | 787.5 |
| 1905 | 26,197 | 5,150 | 200,593 | 762.1 |
| 1906 | 27,481 | 4,055 | 202,561 | 693.5 |
| 1907 | 31,894 | 2,741 | 171,452 | 635.8 |
| 1908 | 25,156 | 3,328 | 198,353 | 777.2 |

| Year. | Purchased ore. (long tons) | Gold production from purchased ore (troy oz.) | Silver production from purchased ore (troy oz) | Copper production from purchased ore (long tons). |
|---|---|---|---|---|
| 1906 | 8,570 | — | — | 151.3 |
| 1907 | 11,951 | 66 | 5,072 | 220.6 |
| 1708 | 21,209 | 553 | 13,412 | 374.9 |

Before 1906, they did not purchase ores.

The number of labourers was, at the end of 1908, for mining 610 persons, for dressing 238, smelting 113 and for other purposes 1,001, thus making a total 1,968 persons.

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## THE POROPETS COPPER MINE.

The Poropets mine which was opened one years ago, is situated some six miles from Poropets station on the Mororan line of the Hokkaidō Railway.

The deposit which composed by many irregular veinlets is found in considerably variable widths from only half a foot to sixty feet in the broadest parts, in the country rock of the Tertiary tuff. Each veinlet consists of quartz, in which copper pyrite, zincblende, galena and iron pyrite are disseminated.

The contents of the ore are 0.00438 per cent. gold, 0.0043 per cent. silver and 1.25 per cent. copper.

A winding engine is operated by a portable boiler, and a pulsometer is used for the underground drainage. The mine stuff is spalled and sorted into small ore, fine ore, and grain ore, the small ore being washed in water.

The ore is directly smelted in three water jacket furnaces, three feet in diameter, together with iron oxide ore and limestone as fluxes. Both coke and charcoal are used as fuel. The blast is furnished by one No. 8 Root's blower. The power plant is made up of one 80 H.P. horizontal tubular boiler, and one 20 H.P. portable horizontal tubular boiler, one 80 H. P. engine, one 20 H.P. winding engine, one 125 H.P. vertical turbine for the blower, one 12 k.w. dynamo, and one 6 H.P. motor.

The labourers employed are 267 persons:—

Miners 49, dressing hands 46, smelters 23, transporters 22; workmen 30 and coolies 97.

Products in 1908.

| | |
|---|---|
| Ore | 7,432 long tons. |
| Gold | 6,559 troy oz. |
| Silver | 6,629 troy oz. |
| Copper | 69 long tons. |

Two 575 H.P. water turbines are now being projected to be installed with the utilization of the stream of the Poropets. For the treatment of the poorer ore, a new cyaniding mill will be commenced before long.

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## THE KOSAKA COPPER MINE.

The Kosaka is the largest mine not only in Japan, but also in the Far East, and is now in its golden age; it however has passed its adult period. It is situated at the end of the line of the Kosaka railway company, which began its running in 1908 with the purpose of the transportation of purchased ores etc., and the export of good timber from an inexhaustable forest near there. Formerly the oxidized part was mined for silver, and subject to Augustin process, but this part did not last for a long time and it seemed that the destiny of the mine was to stop its working when the other part of the doposit was found which K. Takeda succeeded in pyritic smelting in 1897 (this was the first adoption of pyrite smelting in Japan); since that time the mine has continued to develop as a copper mine up to such prosperity, as to make the town of Kosaka which contains about 30,000 inhabitants. The deposits which have brought this prosperity, are composed of the so-called "black," "yellow" and "siliceous" ores which are analysed as follows:—

| Average analyses of 8 months in 1909. | Au | Ag | Cu | Pb | Fe | Zn | $SiO_2$ | $Al_2O_3$ | $BaSO_4$ | S |
|---|---|---|---|---|---|---|---|---|---|---|
| | % | % | % | % | % | % | % | % | % | % |
| Black Ore | 0.00013 | 0.0141 | 2.43 | 2.28 | 15.64 | 9.80 | 8.11 | 6.96 | 30.35 | 22.71 |
| Yellow Ore | 0.00002 | 0.0041 | 2.34 | 0.47 | 26.83 | 3.15 | 13.72 | 7.58 | 12.10 | 31.93 |
| Silicious Ore | 0.00001 | 0.0027 | 1.97 | 0.26 | 19.44 | 1.48 | 41.47 | 6.80 | 5.37 | 21.81 |

"Black ore" is an intimate mixture of zincblende, galena and baryte and has a black colour as its name indicates and a very strong basicity. "Yellow ore" is iron pyrite; it occurs sometimes in crystalline texture and at other times in massive. The former is pure pyrite in sandy form and the latter is very hard quartzose one. The oxidized part of these ores was so-called "Earthy ore" which was mined at the time when it was a silver mine. "Siliceous ore" was found in 1896, and was formed by the impregnation of copper or iron pyrite into tuff-breccia. The occurrences of these ores are very irregular, but black ore exists mostly at the uppermost part and siliceous ore at the lowest level, yellow ore occurring between them. The dimension of the black ore part is 800 feet by 140 feet at the level about 200 feet below the outcrop, but 2,000 feet by 800 feet at the same level when all the ores are taken into account and the present depth of the excavation is 500 feet from the outcrop. The geology of the district consists of liparite, dacite, propylized andesite, augite andesite, Territary tuff and its breccia, shale and Quartenaries.

The complete excavation of such a large mass of deposit must be a difficult matter. The question whether it should be worked by open-work has been raised long since, because the underground supporting became almost impossible, also the spontaneous oxidation of the sulphide ore causes a very unhealthy condition of the atmosphere for the miners. Under these conditions, the open-working method will be employed in future as the chief means of mining.

From September 1908 the ores were thus to be gained chiefly from the open-work nevertheless 5,600 long tons of siliceous ore in 30,000 long tons of ores, which is the whole estimated quantity required per month, is to be got from the underground working. The deposit was approached by four adits of 300—1500 feet in length and divided into three horizontal sections by them, each of which is subdivided into thirteen vertical parts. They are again divided into many portions of 75 feet wide and 7 feet high. Alternate hexahedrons of the smallest division in the lowest level of one of three large sections are excavated at first; after the settling down of the packing which has been put into the excavated spaces, other alternate hexahedrons will be excavated taking the settled packing as a pillar and a similar working will be continued to the high level. The above statements are for underground working. The open-work was formerly employed in order to obtain packing material for the underground workings. The volume to be excavated by open-work in future will be 2,200 feet NS by 600 feet EW at the top, and 630 feet NS by 90 feet EW at the bottom, and from 70 feet to 380 feet in height, the volume of the overburden being 107,000,000 cubic feet, and it will be worked up in six years. The sides will be sloped at 45° and divided into steps 25 feet high the width of which being broader than 12 feet and on which 12 lbs. rail will be set. At present 20,000 long tons of ore are produced from the open-work which shows an increase of 50% the amount of ore mined per head by the underground working. The mine water amounts only to 12 cubic feet per minute which issues from the lowest adit, as the surface water is made to flow away to other places. This water contains some copper, which with other bases is precipitated by lime, filtered by filter presses and sent to the smelting works. The chief machines used in mining are as follows:—

Two 75 H.P. Leyner's air compressors, one 120 H.P. compressor of the same type, thirty-four pneumatic rock drills, one 20 H.P. sinking pump, one 10 H.P. sinking pump, two underground hoists of 23 H.P., and several self-acting planes and endless ropes, etc.

Since the adoption of the open-working system, fast exploration in the underground workings can not be expected; therefore it is intended to exploit by boring the silicious ore, the full extension of which is still unknown.

The smelting of ore poorer than 2.5% copper results from self-fluxing properties of the ores and good practice in pyrite smelting, etc.

The ores mined are brought to the ore depots, which are one mile distant from the mine, in a train of 15 tubs each 2.3 long ton capacity drawn by a 100 H.P. electric mine locomotive of the General Electric Company on the railway (30 lbs. rail and 30″ gauge), there being 21 locomotives for this and other purposes, and the total length of the rail being 12 miles. The ratio of "black," "yellow" and "silicious ore" treated is about as 5: 2: 3., besides which 4% of ore from the Tokitō branch mine and 4% of purchased ores are to be treated. The depots are built on the slope of a hill at the back of the furnace plant and are 420 feet long, 49—60 feet high, in a slope of 40°—45°, having a capacity of 5,000 long tons; and that of fuel has a capacity of 1,000 long tons. Before these ores are fed to the furnaces, they are sized by grizzlies and trommels into 7½—2½ inches 2½—3/8 inches and smaller than ⅜ inches; the first size is 44.40% of the total ore, the second 24% (the both are directly fed to ore smelting), and the last 31.6% which is made into 3 lbs. bricks with two hundred and eighty 66 lbs. wooden stamps and forty-eight 112 lbs. steel stamps driven by 95 H.P. motor. The ratio of mixing is 8 parts black ore, 7 parts yellow ore and 5 parts silicious ore. The pot-roasting has just passed its experimental stage and four pots of 6 feet dia. and 4 feet in depth are in process of erection; for the blast of which one Root's No. 5 blower driven by 35 H.P. motor will be erected. The pots have cone-shaped projections at the bottom for the uniform distribution of the blast and the easy breaking of the sintered mass, they have also a distribution cone for charging. The breaking will be performed by the falling of cast-iron weights. In one pot, at least 4.1 long tons of ore are to be treated seven times a day, at a cost of 7.5 d. per long ton. At first only black and silicious ores are to be treated. Ores and briquettes are carried to the furnaces by 0.5 long ton travelling trollies from which the loads are dropped directly into the furnaces. As for ore-smelting furnaces, there are five 25′×3.5′, one 19′×3.5′ and one 64.5′×3.5′ furnaces, having 32, 24 and 116 tuyeres of 6 inches diameter respectively, and the height from the tuyere to the charging floor being 11.52 feet for the former two and 19.6 feet for the latter. The tops of the furnaces are left open, just beneath which wing-shaped flues are placed from the longer side of the furnaces. The matte is syphoned from the forehearth at front of the furnaces into matte tapping cars like Kilker's patent. The 60 feet long furnace has tuyeres at two different levels and one forehearth at each short side. It was the longest furnace in the world when it was built. The largest one smelts 450 long tons of charge a day, the middle ones 220 long tons and the smallest 170 long tons with 32 mm. blast, consuming 2.6% tuyere coal and coke which is used only when in difficulties. The charge cousists of 46% black ore, 15% yellows ore, 29% silicious and 10% foul slag. Two No. 6, five No. 9, one No. 10 Thwait-Root's blowers and two H.P. & F.M. Root's No. 8 blowers supply the blast for all ore-smelting furnaces, driven by 500 H.P. motors. The slag contains 0.000006% Au, 0.00085% Ag, 0.323% Cu, 0.38% Pb, 22.94% Fe, 7.46% Zn, 34.84% $SiO_2$, 6.19 $Al_2O_3$, 17.15% BaO, 0.44% S and its specific gravity is 3.676. It is granulated after passing through a cleaner, and flows to a tank in front of the furnace-building from which the slag is put in tubs by means of 150 H.P. dredger, and is carried to the dump by electric locomotives which will be replaced by a double system wire rope of 750 long tons capacity per day. The chimney for the ore-smelting furnaces is 200 feet high, 16.5 feet in dia. at the top and is placed 70 feet above the charging-floor; the smoke from this chimney can be seen from a distance of 8 miles. The first matte assays 0.001191% Au, 0.1157% Ag, 29.56% Cu, 7.21% Pb, 25.31% Fe, 8.12% Zn, 0.91% $SiO_2$, 0.96% $Al_2O_3$, 0.32% BaS and 25.54% S, the specific gravity being 4.704. This matte is concentrated to 47% Cu, matte in 15.1′ × 3.3′ furnace by smelting with 32% oxidized silicious ore and 4% sintered matte from Hereshoff calciners. This second matte and third matte from the reverberatory furnaces is crushed into $\frac{1}{16}$ inches in the crushing plant. The crushed matte is roasted to 4.4% S, in the ten 14′ dia. Herreshoff calciners in which about 10% silicious fine-one is mixed in raw matte to prevent it from sintering. The calciners are driven by 25 H.P. motors, and each has a capacity of 9 long ton a day. The roasted matte is treated in one of three 30′ × 8′ English reverberatory furnaces with 40% raw matte, and partly made to bottoms containing 0.00434% Au, 0.44313% Ag, 95.395% Cu 2.750% Pb and third matte of 77% Cu. The bottom is refined into anode copper containing 99% Cu, 0.004253% Au and 0.4303% Ag in one of three 14′ × 5.3′ reverberatory furnaces. Slags from the above and latter treatment are smeled separately in a 10′ × 3.3′ furnace into leady copper, which is subjected to liquation. The liquated copper is added in the charge of anode-making reverberatory, and the liquation lead is classified into refined lead and zinc scum in Park's pan; the former contains 99.6 Pb and is sent to market; the latter is made into rich lead by driving zinc in graphite crucibles, and is then fed with anode-slime from electro-refining into two English cupellation furnaces of 5.5′ × 5.75′ hearth area. The blast of concentration and refining works are all supplied by three Thwaits-Root's No. 6 blowers driven by 120 H.P. motors. The last bullion assays 0.99887% Au 98.48423% Ag and 0.3912% Cu; it is sent to the Imperial Mint at Ōsaka. The litharge produced in the earlier operations is recovered into lead, and that from the last period is worked from bismuth with wet process. The electro-refining plant is prepared with 500 vats, which have 88 cathodes and 20 anodes respectively containing 100 cubic feet electrolyte of 11.5% $SO_3$ and 3.5% Cu at 40° C, four 165 k.w. synchronous motors, four 150 k.w. motor-generator and other necessaries, auch as cathode and acid making vats, converters, distillation tanks and crystallization sumps. The anode slime assays 0.36% Au, 37.28% Ag, 7.46% Cu, 1.85% Bi, etc. which is dried in four 5.5′ × 12.3′ drying furnaces and fed to the cupellation furnace after leading. The electrolytic copper contains 99.36% Cu, 0.00178% Ag, 0.003% Bi and Sb and a trace of Fe and Zn, which is sent to market, it amounts to about 700—750 long tons per month.

The concentration and refining works will be gradually replaced by bessemerizing of the first matte; the reason why the proprietors did not apply this simple method previously was from fear of the loss of the noble metals in this process, but they have ascertained by entailed experiments with two of 1.5 long ton cylindical horizontal converters that this was an unnecessary anxiety. The erection of a plant, in which two stands and eight shells of converter with turbo blower are prepared, has just been started and will be completed at the middle of 1910, when 25 long tons of copper will be made in a day.

The source of power is obtained from four water-falls in the river Ōyu, the furthest of which lies 22 miles east of the mine (the high tension transmission of three phase alternate current electricity applied there, was the first in Japan); the generating stations being as follows:—

| Station. | Head | Water per minute. | Water-wheel. | Dynamo. |
|---|---|---|---|---|
| No. 1. | 104′ | 8,000 cubic feet. | 150 H.P. Pelton<br>850 „ Turbine | 150 k.w.<br>500 „ |
| No. 2. | 104′ | 8,000 „ „ | 850 „ „<br>250 „ „ | 500 „<br>150 „ |
| No. 3. | 75′ | 10,000 „ „ | 250 „ „<br>1,000 „ „ | 105 „<br>600 „ |
| No. 4. | 150′ | 10,500 „ „ | 1,200 „ „ | 750 „ |

The voltage of the dynamos is all 3,450 which is raised to 11,000 volts and transmitted by 180,000 feet long wire to Kosaka substation which consists of 42 transformers and 25 switch boards and is then transformed in suitable voltage to 56 induction motors, 8 synchronous motor-generators for electric locomotives and refining, the total H.P. of them being 3,800 H.P. There are about 7,000 arc lamps. Besides this there are two 200 H.P. boilers for the heating of electrolyte in electro-refinery, 120 H.P. Pelton for wire ropes and locomotives of the railway company. The number of the labourers was 1,377 for mining, 1,621 smelting and 529 workmen, making a total of 8,295 at the end of 1908.

Ores mined and purchased, and productions:—

| | Ore. mined. (long tons.) | Ore. purchased. (long tons) | Gold. (troy oz.) | Silver. lbs. | Copper. (long tons) | Lead. (long tons) | Bismuth. lbs. |
|---|---|---|---|---|---|---|---|
| 1904 | 241,945 | — | 4,739.6 | 31,166.3 | 3,528.6 | 182.9 | — |
| 1905 | 319,490 | — | 8,672.4 | 73,604.8 | 6,512.2 | 310.4 | — |
| 1906 | 339,833 | 1,575 | 9,775.2 | 79,349.7 | 6,618.5 | 392.9 | — |
| 1907 | 371,088 | 18,421 | 9,775.2 | 93,304.7 | 8,215.1 | 542.9 | — |
| 1908 | 349,785 | 12,950 | 10,490.8 | 98,559.3 | 7,086.2 | 372.2 | 787 |

## THE OSARUZAWA COPPER MINE.

The Osaruzawa Mine is situated 10 miles south of the Kosaka mine. Its ore reserve is said to be inexhaustable. The discovery of the mine can be traced as far back as the eighth century, and in old times it was worked as a gold mine. The present company took possession of this mine at the end of 1894.

The ore deposit consists of true fissure veins of various strikes and dips, in Tertiary and volcanic rock. The former consist of shale and tuff; the latter are liparite and propylite. The ore consists of cupriferous iron pyrite and its secondary minerals, sometimes contains zincblende and galena, the gangue is chiefly quartz sometimes baryte. The width of the ore bearing part is commonly 6—8 inches, but 10—20 feet width will often be met with and the tenor of the mined ore is 3—4% Cu on an average.

The veins were approached by adits, but as the mountain has gentle slope, the lower adit can not be excavated, hence the lower working must be done by shafts They are worked as three independent mines i e. the Motoyama, the Tagōri and the Akasawa; it is intended to connect them under the ground. The first produce 50% of the total amount of ore mined. The overhand stoping method is employed, its breast being 6 feet and the sole 15 feet, and the width being greater than 5 feet. Only for the level driving, which necessitates hastening, rock drills will sometimes be employed, for which three of Water-Leyner's 5″ × 2½″ rock drill and one of 12″ × 4″ tandem two stage air compressor of the same company driven by Westinghouse 50 H.P. induction motor are preserved.

There is one blind shaft in Motoyama which is 6.5′ × 14.3′ large, 347 feet deep, and the tubs are wound up by Lidgerwood's double drum friction hoist driven by 35 H.P. induction motor of the G.E. Company. After underground sorting, ore richer than 15% copper is carried directly to the smelting works, and the ores poorer than that degree are classified into middle ores and third class ores, which have about 8% and 3% of copper respectively. Both are brought to the dressing house, which stands 500 yards distant from the adit mouth of Motoyama. The middle ore is subjected to spalling and cobbing, and its middling is treated like the third class ores.

The insufficiency of the water for dressing is the great difficulty felt in this mine, only 4—5 cubic feet of water per minute is commonly available for this purpose, and in summer 0.3 cubic feet will often be met with. Therefore the treatment before jigging is all done without water and all the waste water is so repeatedly used, that frequently the water for dressing assumed the blue colour of copper salts. For this reason it is intended to pump up water from a river which runs two miles to the eastward and 500 feet below.

The dressing is performed with grizzlies, trommels, one 7″ × 10″ Blake crusher, one 30″ × 16″ Style B roll of Allis Chalmers, one 24″ Cornish roll, one 25′ Hancock jigger, four 5′ dia. Huntington mills, pointed boxes, two Wilfley tables, one Pinder concentrator, two 4′ × 12′ Frue vanners and two centrifugal pumps. The total sum of the horse power of the motors used in the dressing is 155 H.P. The present method of dressing is rather in the experimental stage. The method of feeding and discharging of Hancock jigger is done by hand; it is moved by 5 H.P. motor and strokes 189 times a minute. It treats 15 long tons of crushed ore (½ inches), using 15 cubic feet of water per minute and producing 33% concentrate and 30% middling. The most eminent success in the dressing is the result of the employment of Hancock jigger. It was set up at the middle of 1907 instead of fifteen coarse Harz jiggers. This is the first introduction of this type of jigger into our country. The water, which come through the dump of the tailings, is subjected to precipitation method, about 30 long tons of cement copper being produced a month, the analysis of which is about 60% Cu on an average.

Up to April 1908 the metallurgical plant had been a very old fashioned one, when a fire reduced the plant to ashes, since that time it has been renewed and was ready for working at the end of 1908.

The products of the dressing contain more than 70% fine, so that the treatment of the fine ores is an important factor in the metallurgy at this mine. The fine is roasted in eight Herreshoff roasting furnaces of air cooling type. The roasted fines are mixed by a mixing-machine moved by 10 H.P. motor with the slimy mud produced in the dressing, and then made into briquets by 52 steel stamps of 82.5 lbs. weight and dried in 16 drying furnaces. The roasters are moved by 20 H.P. motor with three stage centrifugal pump for the circulation of the jacket water for the smelting furnaces. The pyrite smelting had long been practiced, but since the pot-roasting proved to be more satisfactory, it has been decided that fine ores would be treated by pot-roasting, while the lump ore will be smelted in its raw state. Present treatment of the fine ores will be replaced by four pot-roasters in the near future. Though pot-roasting is rather a trite method yet almost all mines in our country are going to adopt the process sooner or later. For one pot of 8 long tons capacity, one Root's No. 3 blower is equipped, which is moved by 30 H.P. motor of General Electric Company; yet this blower is estimated to be sufficient for two pots. They are now making grounds for three pots to be added in row to the present one pot. 8 long ton ores are fed in 6 or 7 times in one operation after the earlier charge shows fire upon its surface. The charge without limestone have been proved to take a longer time and to give more fine in the product. The whole operation lasts from 8 hours 20 minutes to 9 hours 30 minutes using the blast of 30—36 mm. at the end; but when the workmen get skillful, it may be shortened to 8 hours. The content of sulphur, in the charge is commonly 19.21 %, that in the product 5—6%. The product becomes 70—80% by weight of the charge, and the fines to be returned are 15—20% of the product.

There are three blast furnances of which the two smaller ones are used only in the case of repairing the largest one. The latter one is 180 inches by 42 inches at tuyere level and provided with ten 4 inch tuyeres on each side, but nothing on end. The charge consists of 1.2 long tons of ores containing 7.51% Cu and 66.34% of metallurgical products to the ores, 18.9% of limestone (All these figures are taken from the average results of the first half of 1909). The capacity of the furnace is 70—180 tong ton of the ores, 80 long tons being its average. The matte of 34.8% copper is syphoned from the forehearth into pots and carried to the refinery in a molten state. The slag contains 0.4% Cu. The next furnace is 96 inches by 36 inches and has twelve 6 inch tuyeres and the last furnace 45 inches diameter at tuyeres. The blast pressure is commonly 38 mm.; one No. 7. Thwait-Root's blower and two No. 4 ones of the same company are moved for the smelting and refining by 100 H.P. motor manufactured by the Kōbe Mitsubishi shipyard.

As to refining, there are ten of the Mabuki hearths, which are constructed with charcoal powder and clay, being three feet in diameter, 1.8 feet deep. The Mabuki is a primitive process of bessemerizing and has been in practical use among us for a long time. Though it is simple and depends solely upon labourer's skill, yet pretty good results are obtained together with the very low initial cost of its erection, so that it have caused almost all mines in our country to adopt the process and to continue its use even up to to-day. 4—5 long tons of 36.3% copper matte is charged in the hearth in a molten state and blown for 26—30 hours at 40 mm. pressure into blister copper of 98—99% Cu. The blister copper contains but little gold and silver, it is shipped to the Ōsaka Refinery of the same company where the noble metals are recovered.

The generating station for the whole motive power is situated about 7.5 mile south-east, where 150 k.w. three phase armature rotating dynamo of the G. E. Company is driven by 250 H.P. Pelton wheel and 200 k.w. field rotating dynamo of G.E. by Escher-Wyss' 300 H.P. Francis turbine. In the near future another generating station will be erected on the same river course, three 500 k.w. dynamo will be gradually set up there, when the production will be increased.

At the end of 1908, 693 persons were employed in the mining department, 135 in dressing, 64 in metallurgy and 570 for miscellaneous works, thus making a total of 1,502 persons.

The ores mined and products during the last five years are as follows:—

| | Ore mined. long tons | Gold. troy oz. | Silver. troy oz. | Copper. long tons. |
|---|---|---|---|---|
| 1904 | 17,905 | 143.3 | 49.2 | 1217 |
| 1905 | 51,082 | 161.8 | 2,311.4 | 1254 |
| 1906 | 62,447 | 275.4 | 14,754.3 | 1304 |
| 1907 | 64,763 | 335.3 | 26,333.6 | 1174 |
| 1908 | 54,048 | 412.7 | 25,219.0 | 1358 |

## THE ANI COPPER MINE.

The mine is one of the famous old mines in our country. It was opened about three hundred years ago, and the Ani mine is the general appellation of several mines named Ozawa, Kayakusa, Maki, Ichinomata, Ninomata, Sammai and Mukōyama. The mine is situated in the south-eastern part of Akita county in Akita prefecture, and is surrounded by many high mountains, the height at the smelting plant is 269 feet above the sea level. The climate in winter is severe, the temperature being sometimes down to 12° C below the freezing point.

The mine district consists mainly of eruptive rocks, such as granite, liparite, augite andesite, and sometimes Tertiary and Quaternary rocks, but the veins are mainly found in liparite, augite andesite and Tertiary rocks. There are about one hundred and fifty veins, and these are all fissure filling ones, and these can be classified into two groups in general, the strike of one group is EW and the other is NS. Ozawa, Sammai and Maki belong to the former, and Kayakusa, Ichinomata to the latter. The richness of the ore varies very irregularly, but in many cases the ore becomes rich at the intersection of two veins.

As already described, all veins belong to two groups, hence a cross cut is driven to meet many parallel veins of one group and for the downward prospecting, a vertical shaft is sunk at a place where veins accumulate or in the bonanza of the main lode.

Levels are driven at every 82 feet distance and in the rich parts overhand stoping is adopted for mining, and in the other part only the place is worked which is profitable for mining. Mine water from a lower part than the adit is pumped out by electric pumps, and as the mine water contains scarcely any copper compounds and acid, it can be poured into the river freely. For transportation in the mine, single and double lines of 12 to 9 lbs. rails are laid on the main transportation levels, and ores in tubs are carried out by horses, manual labour and winding engines.

As the mines scatter in the mountainous districts, it is not at good condition to bring all the crude ores into a central dressing mill. Therefore each mine is provided with a simple dressing mill which vary only in the quantity of ore that can be treated, but the dressing method is the same in general. Hence we shall now describe the method of one dressing mill. The ore is subjected to underground dressing and is classified into three kinds, that is first ore, second ore and rubbish; the first ore is carried out in straw bags, the second ore in tubs, and the rubbish is used as packing material for excavated places. The first ore is rich, hence to avoid the losses in dressing various treatments possible are omitted and the following simple method is applied, the larger lumps are subjected to spalling and cobbing, while the smaller ones are sized by trommels, the oversizes are fed to picking tables, and the undersizes are sized by trommels again. By these treatments the first ores are separated into headings and middlings, the latter are treated similarly with the second ore. The second are treated is somewhat complex, the ore is crushed, the larger sizes are subjected to hand pickings, and the smaller one is sized by a series of trommels and subjected to jigging. The tailings from the jigs flow in pointed boxes and are concentrated with Wilfley's concentrators. The total sum of crude ore treated by all the dressing mills is 50,000 long tons a year and the dressed ore amounts to 14,800 long tons with an extraction of copper, amounting to eighty-six per cent. Dressed ores are classified into four according to their sizes, that is:—

| kind. | size. | contents. |
|---|---|---|
| Lump ore | 8 mm. | 16.0% |
| Grain ore | 8 to 4" | 12.7 ,, |
| Sandy ore | 4 to 1" | 70.6 ,, |
| Slime | Smaller than 1" | 0.7 ,, |

As we can see in the above table, there is a large percentage of fine ore, which is due to the fact that the copper ore is intmately mixed with quartz, hence to take away the silica (quartz), it is necessary to crush it into the fine sizes, but still 40% of silicia is contained in the dressed ore and 10% Cu on the average.

This operation is classified into three stages, that is to say, roasting, ore smelting and matte smelting.

Roasting:—All dressed ores are roasted, the fines are briquetted by hand hammering, and the briquets are dried by the heat of the waste gases from the stalls and blast furnaces, the dried briquets are piled with lumps in the stalls layer after layer, and are finally covered by the fine sizes, the required time for one roasting operation is about three weeks, the capacity of a stall being 24 long tons. They are 12 feet wide 8 feet long and 6 feet high, there being 45 of them.

Ore smelting:—There are two water jacketed blast furnaces with forehearths, the larger one is oval in shape, the length of the major axis is 8 feet 3 inches and the minor axis 6 feet and the area at the tuyere level is 22.6 square feet, this treats 44 long tons of ore a day; the smaller one is rectangular in shape, its dimensions at the tuyere level being $5'6'' \times 3'.0''$ and it treats nearly 30 long tons of ore. The latter is not usually used but is reserved in provision for some future necessity. The ore contains too much silica to produce a proper matte, hence raw fine ores are added and limestone is used as a flux, and the required amount of coke is 20% of the ore. The molten matte is tapped intermittently and poured directly into the matte smelting hearth, and the slag flows out continuously which is carried away to the dumps by wheels. The degree of concentration is about four.

Matte smelting:—The molten matte is subjected to the "Mabuki process," or the Japanese bessemerizing. The hearth is made in the ground with a truncated conical form (top dia. $2\frac{3}{4}$ feet bottom dia. $1.\frac{5}{8}$ feet and depth 2 feet 6 inches), lined with silicious clay, and is covered by a dome which is made of silicious clay also, having a working door ($10'' \times 8''$) in the front side and a tuyere on one side. At first about 1.5 long tons of molten matte is poured into the hearth from the working door and subjected to a strong blast, as in the bessemerizing process, then sulphur and iron are oxidized and the latter forms a slag, which is raked out occassionally to maintain the surface of the bath as clear as possible and again new molten matte is added as much as the amount of matte in the bath was decreased, this operation is repeated several times and thus each hearth is charged with about three long tons of molten matte at all. The gradual decrease of the sulphides causes the freezing of the molten bath, hence with the use of much charcoal the oxides are reduced to metallic copper, and the molten copper is ladled into iron moulds. The time required for one operation is from 22 to 24 hours and the durability of the hearth is two or three times. The blister copper contains 97—98% of copper and 0.11% of silver, and these products are sent to the Nikko Electrorefinery.

The communications among the mines are effected by means of waggons or light railways. The products and goods are mainly transported by the rivers Ani and Yoneshiro to Futatsui station on the Ōu line, but in winter these rivers freeze up and can not be navigated, hence the transportation is intermitted in that season so that all goods for daily use are brought to the mine in the summer and autumn.

There are dynamos, water wheels and boilers, but the latter are used only in winter, when the water supply becomes scanty. The H. P. are as follows:—

| | Total H P. | Number of machines. |
|---|---|---|
| From water wheels | 100 | 3 |
| From boilers | 135 | 3 |
| From dynamos | 432 | 1 |

Annual productions for the last five years:—

| | Copper ore. long tons. | Blister copper. long tons. | Silver ore. Cwts | Lead. long tons. | Gold and silver bullion. troy oz. | Gold placer. troy oz |
|---|---|---|---|---|---|---|
| 1904 | 12,032.6 | 1,002.62 | 35.79 | 12.15 | 126,587 | 155.251 |
| 1905 | 11,721.8 | 1,038.26 | 15.42 | 19.35 | 101,719 | 124.047 |
| 1906 | 14,662.4 | 1,184.75 | 3.32 | 0 | 51,190 | 74.000 |
| 1907 | 15,684.1 | 1,174.75 | 14.16 | 2.63 | 54,100 | 69.459 |
| 1908 | 14,301.6 | 1,284.60 | 0 | 0 | 44,948 | 49.563 |

Number of labourers:—Miners 1120, timber men 38, miners' helpers 387, carriers 506, dressing hands 47, smelters for the blast furnace 59, smelters forthe Mabuki hearth 13, drivers of machines 79, miscellaneous labourers 746, and women 576, making a total of 3571.

## THE ARAKAWA COPPER MINE AND THE HISAN-ICHI COPPER MINE.

The Arakawa mine is some seven miles eastward from Sakai station on the Ōu railway, to which a tramway has been laid from the mine.

In this district, through the sedimentary rocks of the Tertiary age consisting of tufaceous shale, tuff breccia and sandstone, liparite and certain kinds of andesite have intruded. Traversing these rocks, many mineral veins occur in various widths. They extend for lengths of from 200 to 600 feet and dip to various directions at 55 to 80 degrees. The ore bodies frequently occur in shoots, 400 to 800 feet deep. The chief ore is chalcopyrite associated with other sulphide minerals and quartz. The ore contains 2.3 per cent of copper.

The mine is divided into four main parts, in all of which 85 levels of 35,000 feet in total length have been driven, there being four shafts which are 300, 500, 400, and 600 feet deep respectively. At each shaft, a Lidgerwood single or double drum winding engine is fitted up. The water is raised up to the adits by pumps; these being Escher-Wyss turbine pumps, Knowle's, Deming's and Gould's plunger pumps.

The scheme of hand and mechanical dressings is so complicated that, it can not be fully described in the limits of this paper. Here is only given the plant of the dressing, which consists of two flat washing sieves, three Blake breakers, thirteen trommels, three pairs of Krom rolls, two Huntington mills, two Evan convex tables, nineteen coarse and fine jiggers, four Wilfley concentrators, and two 3 H.P. and two 50 H.P. motors etc.

The monthly production of the concentrates is from 800 to 900 long tons. The lump ore together with the briquetted ore is smelted in blast furnaces and the matte is directly blown in the Mabuki hearths for black copper. The pulp ore is roasted and leached by water and the cement copper is smelted in the Mabuki process for black copper.

The leaching plant consists of thirty-five stalls, twenty-two leaching vats, twelve precipitating tanks, one centrifugal pump: the smelting plant consists of one drying furnace, two water jacket furnaces 4.2 feet in diameter, eleven mabuki-hearths, one No. 5 and one No. 4 Root's blowers. The monthly production of black copper is 72 long tons.

There are four electric power stations—the installed machines are two 45 H.P. and two 35 H.P. Pelton water wheels, two 250 H.P. and two 380 H.P. Francis turbines. By them, eleven dynamos are driven.

The labourers employed are 1,747 persons—mining 1,180, dressing 365, smelting 160 and lixiviation 92.

For future important undertakings (that is, the extension of the working to 1,000 feet below the adits, the enlargement of the dressing works and the adoption of pyritic smelting), a 1,000 k.w. electric central station will be shortly built in addition to the present stations.

Products.

| | Copper ore. | Black copper. |
|---|---|---|
| 1904 | 43,972 long tons. | 871.21 long tons. |
| 1905 | 43,764 „ | 833.36 „ |
| 1906 | 48,409 „ | 815.66 „ |
| 1907 | 55,819 „ | 714.69 „ |
| 1908 | 54,811 „ | 732.00 „ |

The Hisan-ichi mine lies 4.9 miles south-east of the Arakawa mine. Seven veins, varying in magnitude, occur in the Tertiary tuff and liparite. Two of those veins are now being worked. The chief minerals making up the veins are argentiferous chalcopyrite and quartz, associated with tetrahedrite, malachyte, cuprite, galena, zincblende, ironpyrite, hematite and chrysocolla. The ore contains on an average 3 per cent. of copper, with 0.015 to 0.02 per cent. of silver.

Besides three cross cuts, six chief levels are open along the strike, the total length of the latter being some 37,000 feet. One blind shaft is now being sunk. At the Kurototakisawa shaft, one Lidgerwood double drum friction clutch electric winding engine of 100 H.P. is set up.

The system of dressing is also complicated equipment and is as follows:—three Blake crushers, two pairs of Krom rolls, seven Hunttington mills, four Wilfley concentrators, four Cammett tables, six Pinder tables, two grizzlies, seven trommels, twenty-six jiggers, twelve pointed boxes, two pumps, one 5,000 square feet settling tank and six motors.

The monthly production of concentrates is about 8,000 long tons, in which 7 per cent. copper and 0,07 per cent. of silver are contained

The metallurgical processes are carried on by the dry and wet methods. The raw lump ore together with the dried raw ore briquet is smelted in a blast furnace and the produced matte is directly blown in the Mabuki hearths for coarse copper. The pulp ore from the precipitating pond is dried, roasted and leached by water, and from the leached lye, copper is precipitated by iron scraps. The cement copper, together with the matte, is blown up to black copper.

The leaching plant consists of thirty stalls of from 5 to 6 long tons capacity, forty-two precipitating tanks, and one centrifugal pump driven electrically.

The smelting plant is composed of two drying furnaces, two blast furnaces (3.5 feet in diameter at the tuyere levels, and 4.2 feet at the charging sills and 7 feet high from the tuyeres), six Mabuki hearths 3.7 feet in diameter, one No. 3, two No. 4 and one No. 6 Root's blowers.

The monthly treatment of the ore is 800 long tons, from which 84 long tons of argentiferous black capper is obtained.

The electric power is supplied from the Arakawa mine, which amounts to 343 H.P. i.e. for winding 100 H.P.; for dressing 106 H.P.; and for metallurgical works 132 H.P.

The working of the mine to the depth of 1,000 feet below the present adit is being aimed at for the first future undertaking.

The labourers employed are 753 persons in all—miners 314 porters, coolies and others (underground) 154, dressing hands 128 smelting men 91, workmen 66.

Products.

| | Ore. | Copper. |
|---|---|---|
| 1904 | 32,880 long tons. | 613.24 long tons. |
| 1905 | 34,094 ,, | 605.85 ,, |
| 1906 | 34,125 ,, | 651.87 ,, |
| 1907 | 40,099 ,, | 685.01 ,, |
| 1908 | 43,448 ,, | 689.70 ,, |

## THE KANŌ COPPER MINE.

The mine is situated 6 miles north of a town called Kitagata, which stands at the end point of the Ganyetsu route, a branch line of the Tokyo-Aomori Railway. The present company was organized in 1904 with a capital of £512,500 after the failure of many operators; as the so-called "Black ore" deposit of this mine is not self-fluxing like that of the Kosaka mine and is poorer in copper and richer in zinc than at the latter mine.

In Tertiary tufaceous shale and sandstone, two masses of "Black ore" occur, divided by a liparite dyke 100 feet in width. One mass measures 200 feet by 500 feet and the other 100 feet by 200 feet, considering merely the part consisting of so-called "Black ore" which contains about 2% Cu; but it reaches to 1,200 feet by 800 feet when the so-called "Siliceous ore" is taken into account, which is liparite impregnated by cupriferous pyrite and contains 1% Cu.

The ore is chiefly produced from open-working and exploration is done by the improved Chinese boring with good results. At present the open-work is sunk to a depth of 110 feet from the surface of the deposit, on which an overburden lies in thickness of from 40 feet to 70 feet and the working will be excavated to 70 feet deeper which is the same horizon as the lowest adit. The present exploration extends to 70 feet below the adit. The mined ore is sent to the dressing plant by a 206 feet long incline and an endless rope 1,000 feet long.

The ore of 75—55 mm. size is treated in three Hancock jiggers and twenty-seven Overstrom tables after being crushed to $\frac{1}{2}''$ by six Huntington mills of 6 feet dia. Crude ore smaller than 55 mm., which has been crushed to $\frac{3}{16}''$ by three Huntington mills of 5 feet dia., is treated in three Harz coarse jiggers and three Wilfley tables. The smaller size of the middlings from the Harz and Hancock jiggers is treated in six Harz bed jiggers and four Wilfley tables after passing through six trommels. The larger size of the middlings from the coarse and Hancock jiggers is crushed to $\frac{3}{16}''$ by one 4 feet dia Huntington mill and treated in three Harz bed jiggers and three Wilfley tables.

All these machines with 10 H.P. hoist are driven by two 100 H.P. Westing-house's motors and for spare use one 150 H.P. gas-engine and one 100 H.P. motor are placed. Tailings are carried to the dump by tailing wheels and pulp or fresh water is pumped up by two 3′ 6″ dia. centrifugal pumps driven by one 50 H.P. Westinghouse motor, one 15 H.P. pump and two 10 H.P. pumps of the same type.

All the headings of the dressing are recently treated in a magnetic separation plant, though formerly only a part was subjected to it. It is roasted in five 10 feet dia. Herreshoff roasters and after cooling for 12—13 hours on cooling floors is treated in five Ding's double-pole-system magneto-separators which treat about one long ton of the roasts per hour per machine. The de-magnetized product is treated in two bed jiggers, the heading of which after sieving by $\frac{1}{10}$″ sieves contains 44.48% Zn. The undersize of the sieve which has much baryte is subjected to a flotation process which is in the course of experiment. The machine of flotation resembles the Macquisten's tube used at the Adelaide reduction works in the U.S. and makes original stuff of 20% Zn into concentrate of 55—60% Zn content by two-times repetition, consuming 40 lbs. of 64° B. sulphuric acid and 1.2 litre heavy oil per ton. Power in this part is 7 k.w. for the magneto-separators, 15 H.P. for the Herreshoff furnances. At present 200 long tons zinc concentrate is produced a month, but in the immediate future it is to be increased to at least 300 long tons concentrates of 55% Zn content. For this the erection of the flotation plant has just been finished. It is also the intention to treat by flotation all the de-magnetized stuff and middlings of the last jiggers for which it is stored.

The fine one is briquetted by tweenty-five steel stamps and the briquets are dried by five drying furnaces and fed to the charge of smelting. There are 3.3′ × 60′ blast furnaces with ninety-one 6″ dia. tuyeres, two 3.3′ × 9′ ones having twelve 6″ tuyerers and a 3.3′ dia. one which has six 6″ tuyeres. The ore is first smelted into a matte of about 28% Cu and next into one of 50% Cu which is converted into blister-copper by the Mabuki hearth by applying oil for fuel. Two Root's No. 9 blowers moved by 150 H.P. motor supplies the blast; for extraordinary service two Root's No. 3, one Root's No. 5 and one gas engine are reserved. They are now testing pot-roasting and electro-refining of blister copper. The blister copper contains 97.5% Cu, 0.5% Ag, 0.004% Au and 1.2% Pb it is shipped abroad through the hands of the firm of Mitsui & Co.

The generating station stands 15 miles north-east of the mine and is equipped with a 500 k.w. dynamo. There were 734 miners, 148 dressing persons, 182 smelting men and 1,400 miscellaneous workmen at the end of 1908.

The mined ores, etc. are in English tons as follows :—

| Year. | Mined ore. | Purchased ore. | Ores smelted. | Copper produced. | Zinc concentrate. |
|---|---|---|---|---|---|
| 1905* | 512 | — | — | — | — |
| 1906 | 15,473 | 139 | 9,442 | 176 | — |
| 1907 | 29,263 | 573 | 10,283 | 237 | — |
| 1908 | 86,676 | 2,267 | 40,981 | 974 | 9 (only Dec ) |

## THE ASHIO COPPER MINE.

On the upper course of the Watarase river, Shimotsuke, there is the Ashio mine, 14 6 miles south-west near the famous Nikko temples.

The rugged high mountain of the mine consists of liparite erupted through the Palaeozoic formation, which involves clay-slate, sandstone and quarztite. Under the influence of some mountain making forces, numerous fissures were formed in the rocks which were then filled with minerals.

The crustification of minerals is in such a order as: (a) quartz (b) chalcopyrite, associated with some irom pyrite, (c) pyrite, zinc-blende and galena and lastly (d) quartz again. Among the extraordinary numerous veins, over one hundred have been already touched and sixty of them are being now worked. According to their strikes, they may be classified into two groups: the first group or sixty degrees group (or the Yokomabuhi group, after the name of the most typical vein; under this group, 56 veins may be placed); and the second group or the one hundred degrees group (or the Shinseibi group, under which 39 vein may be placed).

The longest of the levels, which have been driven along the veins of the two groups are respectively 5,750 feet and 2,480 feet.

* Before and in this year the mine was still in development.

The chalcopyrite occurs in crystals and crystalline masses in the gangue. Frequently, there occur also native copper, cuprite and almost all other copper minerals in a small quantities. Other associated minerals are quartz, pyrite, calcite, pyrrhotite, mispickel, galena, zincblende, vivianite, fluorspar and apatite.

The copper pyrite contains silver in very small quantities, sometimes up to 0.01 per cent. In galena as well as blende, silver up to 0.1 per cent. is often contained. Gold is found in traces in the copper ore.

The exploration is carried on by opening cross outs, level, roads, winzes and shafts as usual. The levels are 4 feet by 7 feet for a single track and 8 feet by 8 feet for a double track, which are increased 2 feet in height when electric power lines are to be suspended. The total present length of the levels amounts to 540,846 feet. While the working system usually adopted is overhand stoping, it frequently happens that only enriched parts are followed and dug without keeping any systematic form of excavations. There are 1,447 working places, occupied by 2,833 miners.

In important level driving and shaft sinkings, rock drills have been used. The drills now in use are fifty three Water Leyner, twelve Little Wonder and one Ingersoll. Seven Leyner air compressors are used, the power requiring 550 H.P. totally. The total work done of compressors amounts to 2,948 cubic feet per minute of air at a high pressure of 100 pounds per square inch.

Since 13 or 14 years ago, cement copper has been extracted successfully from the mine water. The monthly production of cement copper averaged some 29 long tons in the last year (1908), which contained 58.16 per cent. copper.

Electric railway is laid in the main adits, their total length being 30,630 feet — double tracks 24,650 feet and single tracks 5,980 feet. Electric locomotives are of two sizes, viz: 15 and 20 H.P. and their tractive power is respectively nine and twelve loading cars.

There are ten shafts throughout the mines, the deepest ones being 933 feet, 842 feet, 778 feet, etc. Almost all of them are blind, all the shafts except one being fitted up with winding engines. The dimensions of important one are shown below :—

| Shaft. | Size of drums Diameter. | Width. | Power of motor | Power used. |
|---|---|---|---|---|
| First shaft on the Kōsei vein | 4 ft. 6 in. | 2 ft. 8 in. | 100 H.P. | 70 H.P. |
| Kotaki shaft | 4 ft. 0 in. | 2 ft. 0 in. | 50 H.P. | 40 H.P. |
| Third shaft on the Yokomabu vein | 6 ft. 8 in. | 3 ft. 0 in. | 50 H.P. | 35 H.P. |

Water below the main adits is pumped up there. The pumps are fifteen in kind and twenty eight in number with various working capacities. Among them, one 100 H P. Escher Wyss turbine pump is considered very effective. This pump consists of a set of two pumps, which are capable of working independently or in combination; that is up to a head of 235 feet, the two can raise water of 50 cubic feet per minute, independently, while with a head of 470 feet, they can life up 50 cubic feet in their combined work. To provide against emergencies, a Worthington sinking five stages turbine pump was erected and tried, last year (1908).

Innumerable old excavations of the outcrops of veins, communicating with the present underground workings, have been made water-tight by timber stretched between the side walls and masonry works flush with the ground surface. The great part of the mines are ventilated naturally, while two centrifugal fans are in use only for certain deeper workings, where the deficiency of air takes place. The winding and transportation of the ores in the underground passages are operated by electric power. The main levels are illuminated electrically.

The dressing mills stand at the entrances of the three adits, the mine stuffs being conveyed out from the corresponding mining parts.

The mine stuffs are of two kinds, namely the first ore which is rich ore got in the workings, containing at least 11 per cent. copper and the second ore which chiefly consists of vein stuff having copper minerals in small pieces or grains disseminated and in which about 2 per cent. copper is contained. The rich ore is treated by both the dry and wet methods in the Honzan and the Tsūdō dressing mills whilst it is treated by the dry way only in the Kotaki mills. In each the middlings from the rich ore, together with the second or poor ore is sorted into concentrates and wastes. For the treatment of the second stuff, which contains much clay and gangue, 578 cubic feet of washing water per minute are needed throughout all the three mills.

The schemes of these mills differ somewhat from one another. The working system of the Tsūdō mills will be described below :

Here, in the first dressing mills the first or rich mine stuff is dumped upon a horizontal grate spaced 80 mm. apart, the oversize is spalled and sent back to the grate and the undersize to the next 25 m.m. trommels. The undersizes from these last trommels are classified into fine, grain and lump ores by another double trommels (9—5 mm.), these products being sent to the smelting works. On the other hand, the oversize (80—25 mm.) goes down through 40 mm. trommels to the picking tables, where the stuff is sorted into concentrates (lump ores), iron pyrite, middlings and wastes. The middlings pass successively a Blake crusher, a pair of Krom rolls, a series of three trommels (3.25—17 and 9—5 mm.), coarse jggeris and finally labyrinths.

The middlings from the jiggers are sent to the second dressing mill. In the second dressing mill, the second ore is discharged upon a grate of 70 mm. space. The oversize is spalled and the undersize together with the spalled stuff is classified by 40 mm. trommels. The oversize (70—40 mm.) successively runs down through a picking table, a crusher, a pair of rolls and a series of five trommels (17—2 mm.) while the undersize (40—0 mm.) goes down directly through a series of six trommels. The oversizes of the trommels of the two series run into coarse jiggers; and the middlings from them together with those from the first dressing mill are crushed by a pair of centrifugal rolls and products run down through a 2 mm. trommel into Linkenbach's hydraulic classifiers, from which the first and the second sands go down to fine jiggers. And the pulp from the classifiers enters pointed boxes and then Overstrom or Wilfley slime tables. The middlings from the fine jiggers are sent back to the classifiers and the middlings from all the tables to the pointed boxes.

Dressing Mills.

| | Number. | | | |
|---|---|---|---|---|
| Kinds of apparatus. | Honzan mills. | Kotaki mills | Tsūdō mills. | Total. |
| Iron grates | 4 | 4 | 4 | 12 |
| Picking tables | 17 | 13 | 3 | :3 |
| Trommels | 29 | 20 | 34 | 83 |
| Blake crushers | 1 | 2 | 2 | 5 |
| Dodge crusher | 1 | — | — | 1 |

| | | | | |
|---|---|---|---|---|
| Stamps | 25 | — | — | 25 |
| Krom rolls | 1 set | — | 2 sets | 3 sets |
| Cornish rolls | 1 sets | 2 sets | — | 3 sets |
| Sturtevant centrifugal rolls | — | 1 sets | 1 set | 2 sets |
| Belt conveyers | 4 total length 169.3 feet. | — | 4 total length 239 feet. | 8 |
| Elevators | 14 total length 449 feet. | 12 total length 318 feet. | 13 total length 356.6 feet. | 39 |
| Jiggers | 40 | 31 | 42 | 113 |
| Hydraulic classifiers | 9 | 8 | 6 | 23 |
| Pointed boxes | 4 | 6 | 6 | 16 |
| Overstrom concentrators | 1 | 4 | 6 | 11 |
| Wilfley concentrators | 5 | — | 2 | 7 |
| Cammett concentrators | — | 1 | 1 | 2 |
| Evan slime tables | 4 | 5 | — | 9 |

Motive power used for all the dressing mills—eight motors, the total power of which is 318 H.P. and two Pelton water wheels, the total power of which is 65 H.P.

Production of concentrators in 1908—Pump ore 24,495 long tons—14.34 per cent. copper; grain ore 6,326 long tons—11.50 per cent. copper; fine ore 22,231 long tons—11.32 per cent. copper; and slime 316 long tons—5.55 per cent. copper.

Since the mine was set to work, by the famous Furukawa Ichibei, in 1877, the development of the smelting works may be divided into four periods viz: I. the period of the old Japanese methods of smelting, II. the period of the introduction of the foreign methods of smelting, III. the period of experiments and IV the period of the operation in the new smelting works.

The first period. The old Japanese methods of smelting were inherited. The ore was roasted in stalls called "Dogama" (1.1 long ton capacity each) made of stone and earth and smelted in two "Yamashita" hearths (1.1 long ton capacity each). The annual production of coarse copper was then some 60 long tons.

In 1885, 48 hearths were built in the position of the present smelting works or Honzan and at the same time two No. 3 Root's blowers were introduced and the production of copper considerably increased. Fine ore was treated by the wet method and copper vitriol was prepared. About the last of the period, three Pilz furnaces were erected, but they were soon given up.

The second period : In this period, foreign methods of smelting were successfully adopted. At the beginning of this period, a rectangular brick furnace was erected at Kotaki, and then a water jacket rectangular blast furnace 30 inches by 60 inches was built at Honzan. And soon seven more were added. Thus the old Japanese hearths were all discontinued. In 1893, the Bessemer process of copper was adopted. There were four converters, 5 feet in diameter, by 6 feet 9 inches high, and one cupola for the fusion of matte. Of all eight furnaces, four were enlarged 33 inches by 96 inches to increase the supply of matte. The old roasting kilns were all done away. Lump ores and matte were roasted in kilns of a foreign type ; while fine and granular ores were treated in reverberatory furnaces. Slime was consolidated to brick forms to be calcined in kilns. The production of copper was rapidly increased up to 5,900 long tons in a year, altogether in the Kotaki and the Honzan smelting works. This period ended with May, 1904, when the Kotaki smelting works were stopped and the Kotaki ore was sent to the Honzan smelting works.

The third period : In this period, she smelting works underwent many changes. There were the constructions of a desulphurizing tower for the gas from the smelting and sixty-six stalls, the adoption of the Wright MacDougal roasting furnaces, the invention of a method of enveloping fine ore in molten slag or matte, and so forth.

After repeated experiments for over three years, one blast furnace 42 inches by 204 inches at tuyere level was built for pyritic smelting in 1903. And the roasting of lump ore was abolished in 1906. The working capacity of the converters was greatly increased by the adoptian of agalmadolyte or decomposed liparite for lining, by directing the tuyeres tangentially to an imaginary circle in the shells, and thirdly by decreasing the number of the tuyeres and enlarging their diameter. All types of converters except the Stalmann have been subjected to experience.

The fourth period. The ore roasting was entirely discontinued in September 1906. Two years later, the present new building of iron construction was erected and there were placed in it one furnace jacketed to the charging floor level and two barrel converters of the most approved new type. (The new smelting plant has not yet been completed).

The pot-roasting was adopted in 1908, by which all the fine ore has been found to be made a suitable material for the charge of pyritic smelting.

The smelting processes may be outlined thus: the lump ore, together with the cindered substance produced from pot roasting, is smelted with limestone as a flux and the produced copper matte, together with the cement copper, is blown up in converters for coarse copper.

The fine ore and the sand ore are treated partly by making them into briquets and roasting them in kilns and partly by pot roasting. There are two 7 long ton roasting pots especially made. The roasting pots now in use are made of cast iron 1½ inches thick in a conical form. The diameter is 8 feet at the top and 5 feet in the level of the false bottom. The depth to ths false bottom is 4½ feet. The pots are mounted on cars, which are permitted, when necessary, to move on rails and can be turned by worm gearing. The blast is furnished by No. 6 Root's blowers. Twelve roasting pots will be arranged in two rows. The average daily capacity from the pots will be 70 long tons of fine ore below 3 mm. and 17 long tons of sand ores of 3—8 mm.; the consumption of charcoal and wood being 10 per cent. of the ore. Six pots will be always operated.

All the materials to be smelted are elevated by electric elevators to the charging floor 41 feet above the furnace floor. An electric travelling crane is provided for the conveyance of the matte ladles between the smelting and the Bessemer room.

The blast furnace is made of steel iron plates, has bosh and is surrounded by water jackets for the whole height; the sectional area at the tuyere level is 160 inches by 42 inches and it has twenty four tuyeres, 4 inches diameter. The charge is made at the top. The height of the furnace above the tuyeres is 8 feet 7 inches. The blast pressure is 1⅜ pounds per square inch. The average daily amount of smelting is 90 long tons. The forehearth 12 feet in diameter and 4 feet high is constructed of iron plate, lined with liparite and the parts, which are exposed to the serious corroding action of the molten body, are protected with magnecite brick.

The charge of smelting is made up of the following proportions: lump ore 3,600 pounds, roast 3,500 pounds, briquet 1,100 pounds, limestone 2,200 pounds and coke 650 pounds. The slag overflowing from the forehearth is granulated by water. The matte is at proper times tapped out from the forehearth into a ladle, which is then conveyed to the converter by the travelling crane. The matte contains 38.86 per cent. copper; the slag contains 0.21 per cent. copper, 28.75 per cent. ferrous oxide, 18.85 per cent. lime, 39.98 per cent. silica, etc.

In the Bessemer room adjacent to the smelting room there are two sets of the convertors at present. The Bisbee or barrel converters are 72 inches in diameter and 10 feet long. They are fitted up with eleven tuyeres, 1¼ inches in diameter. They are mounted on friction wheels and can be turned for 190 degrees by means of hydraulic rams. Two convertors are to be usually operated. Blast is supplied by one 100 H.P. air compressor. Its pressure is 8 to 10 pounds per square inch. The copper is somewhat overblown, so that 0.53 per cent. oxygen is present in the finished copper. The fineness of the copper is 99.125 per cent.

In the separate compartment, in front of the Bessemer room, two sets of a ladle cradle, an endless mould chain belt and a chain belt conveyer, with a water tank interposed between the two belts, are arranged in paralled rows. When the ladle turns the molten copper is cast into the moulds, attached to the travelling chain belt. The moulds are conveyed into the water tank.

The present power installation consists of ten electric power stations, for which the streams of the Watarase and the Daiya river near Nikkō are utilized; and turbines amount to 5,000 H.P. and the generating power of the dynamos is 3,824 k.w. Seven Pelton wheels are used in direct gearing for driving aerial rope tramways, blowers, and air compressors, being their total power 507 H.P. The total length of the electric lines is 141,863 feet of which 19,148 feet is in underground. One hundred and fifty one motors—4,128, 364 k.w. and thirty-nine electric locomotive cars—554,000 k.w. are in use.

For the purpose of obtaining more than 5,000 H.P., an enlargement of the present works has been started at Hoso-o, where 2,500 H.P. is now being generated The improved plant will be finished at the end of this year (1909).

Since about fifteen years ago, all the precaution measures have been taken against the injuries caused by fumes, smoke and water from the mining works. Hence the acid fumes in the smoke is neutralized by the shower of lime water and the polluted water also by lime. The plant adopted consists of a dust chamber, an acid condensing tower for the dusty and sulphurous smoke of the smelting works, lime mixers and agitators, ponds for precipitation and filtration of the waters coming from the underground workings, the dressing mills and other sources, and also for the collection of sand and slime suspended in the waters. The rubbish and the slag are dumped upon specified grounds, strongly dammed up by stone and earth.

The labourers employed are 7,274 in total, that is to say, mining 3,191, dressing 487, smelting 80, converting etc. 52, work shop 2,125, transportation, forestry and others 1,339:—

Product.

| Year. | Ore (concentrated) long tons. | Bessemer copper. long tons. | Electro refined. copper. long tons | Silver. troy oz. |
|---|---|---|---|---|
| 1904 | 45,949 | 6,473 | — | — |
| 1905 | 49,592 | 6,534 | — | — |
| 1906 | 50,530 | 6,281 | 430 | — |
| 1907 | 50,598 | 4,534 | 1,728 | 48,993 |
| 1908 | 53,714 | 4,596 | 2,376 | 75,082 |

As there are a great many veins, some one have not been entirely explored and others are entirely untouched, for which cross cuts, varying from 700 feet to 2,000 feet long are being driven or will be set to work at once. In the Sunokobashi region, a shaft of a depth of 600 feet is being sunk for the horizon of the Tsūdō adit, for the purpose of such exploratory works. Three air compressors are being projected to be placed outside of the mouth of the Tsūdō adit, each of them being to compress the air of 1,100 cubic feet per minute at a pressure of 100 pounds per square inch. Each require a 200 H.P. motor. By these compressors, fifty Water Leyner drills are prepared to be used.

A large shaft has begun to be sunk from a point in the Tsūdō adit, where will be a gathering point of ore from many working places. This shaft is to serve as an auxiliary to the existing adjacent one.

As regards dressing, it is being projected that both the second ores and the wastes (below 5 per cent. copper) will be washed to save the fine ores that have adhered to them, and that lump ores above 25 mm. will be subjected to picking. For the treatment of rich fine sand and fine ore, hydraulic classifiers, bed jiggers, and tables will be increased. Thus, in the three dressing mills, an increased yield of 332 long tons will be attained in one year, and the rate of concentration of the poor ore will be advanced to 65 per cent. from 57 per cent. Experiments will be carried on in the Tsūdō dressing mills at first.

## Nikko Electric Refinery.

In the Nikkō Electric refinery, chiefly the Bessemer copper of the Ashio mine is refined; gold and silver contained in it are extracted at the same time. The refined copper is transformed into wire bars, from which trolley wire, telegraphic wire and other different kinds of wire are drawn. Crude copper containing 96 to 98 per cent. copper and very poor in gold and silver, which come from other mines belonged to Furukawa Co., are also refined together. The produced ingot copper is exported to the foreign markets.

The Bessemer copper is refined in a reverberatory furnace to the fineness of 99.44 per cent. copper. It is then cast into ingots of a suitable size for rolling and they are rolled into plates $\frac{1}{4}$ inches thick. The plates are cut off to the length of 24 inches and subjected to electrolysis. For refining, four reverberatory furnaces of from 18 to 23.6 long tons capacity each, are furnished.

In the wire mills, two pairs of rolls (one grooved and another planed) 16 inches in diameter, two shearing machines, one Bates and Peard annealing furnace, etc. are installed.

For electrolysis, Siemen's method is adopted. Two hundred and thirty-four vats are placed, from which fine copper is produced to the amount of 479 long tons in one year. The slime remaining in the vats is smelted in an English cupellation furnace for gold and silver bullion.

The electro-refined copper is melted in a reverberatory furnace for the purpose of making it into a tough pitch like condition and wire bars are prepared from it, from which different kinds of wire are drawn. The finer wires are drawn through diamond dies. The hard copper wires below 150 mm. in diameter are guaranteed for a breaking strengh of over 60,000 pounds and those of larger diameters 150 to 400 mm. of 50,000 pounds; the electric conductivity is warranted to be 98 per cent. of the Mathiessen standard, in case of a breaking strengh of 60,000 pounds per square inch.

The inferior course copper supplied from the different mines is refined in reverberatory furnaces to the fineness of 99.70 per cent. copper to be sent to the markets.

## THE HITACHI COPPER MINE.

The Hitachi mine is in the southern part of Abukuma Plateau by the coast of Hitachi province, some 5 miles north-west of Sukegawa station on the coast railway between Tokyo and Sendai.

The sedimentary strata of this region, belonging to the lower Palaeozoic formation, consists of amphibolite, phyllite, talc schist and limestone. Several argentiferous and cupriferous pyrite beds occur between the strata of the amphibolite which cover a broad area of 500 feet wide and 5,000 feet long. They generally strikes N 45° E and dip to the north-west at 70° but the strikes are found to tend gradually toward the east and west at the western boundaries.

The Honkō deposit, some 1,500 feet long, are distinguished into upper and lower beds; the former again into two small beds of 500 feet and 1,000 feet in length. Their thickness is from 7 feet to 20 feet. The ore contains only 1.5 per cent. copper. The underlying bed widens toward the lower parts over 15 feet wide in 500 feet level which is the lowest level at present and where the ore contains 4.5 per cent. copper. The Kanmine deposits, perhaps dislocated parts of the Honkō deposits by faults, are above 500 feet long and 10 feet wide, they also widen toward the lower parts. The ore contains 5 per cent. copper. The Chūsei bed occurs in the overlying strata above the preceding two beds; and it is the most developed one among all the deposits, its outcrops continuing for 2,000 feet. In the eastern part, where the exploration has most advanced, the beds extend for a length of 1,000 feet, ranging from 15 feet to 55 feet in width. The ore contains 4 per cent. copper.

The contents of the ores from the different parts of the mine are given below:—

| | Chūsei | Kanmine | Honkō. | Senmai. |
|---|---|---|---|---|
| Gold | 0.00012% | 0.00011% | 0.00010% | 0.00006% |
| Silver | 0.00159 ,, | 0.00138 ,, | 0.00144 ,, | 0.00087 ,, |
| Copper | 4·91 ,, | 4.33 ,, | 3.70 ,, | 2.75 ,, |

Boring machines are used for exploration to affirm the presence and character of ores underneath, whilst for underground exploration, rock drills are employed for the rapid progress of the works.

Machines, now in use for the mining work, are four boring machines, three air compressors, twelve rock drills, three winding engines, for sinking pumps and two self-acting planes.

The dressing of the ores simply consists of spalling, sorting and picking. The plant consists of iron grates and endless picking belts of iron construction. The picking house consists of eight rooms and the lowest rooms or bins are provided for the ores ready to be sent away to the smelting works.

The smelting works stand in a valley 2.4 miles distant from the picking house: and between them there is an aerial rope-tramway spanned over high peaks. The ores are smelted by pyritic smelting and the produced copper matte is treated in Bessemer convertors for black copper. The smelting plant consists of ore bins, pot roasting work, briquet work, smelting work converting work and accessory works. They are arranged in steps and connected by inclines or electric railways.

In the ore bins, there are kept not only the ores of the mine but also those bought from other mines. The sieve house is provided for the classification of certain ores into lump, grain and fines by trommels for separate treatment in smelting; and the pulverizing work is supplying quartz for the lining of the convertors. For fastening fine ores, six batteries of stamps, are provided. One battery contains ten stamps, each weighing 117 pounds. The daily capacity of each battery is 14.8 long tons.

Roasting-pots are employed to desulphurize and sintering coarse granular ores. Sixteen pots, 8 feet in diameter and 4 feet deep to the false bottoms, are arranged systematically. Blast is supplied through the entrance 8 inches in diameter below the false bottom. One pot is capable of sintering 14.8 tons of ore per day. The pressure of the blast is 40 mm. of the mercury column.

For the treatment of the ores, two blast furnaces stand there. Each furnace in a rectangular section has a hearth sloping towards the front end of the furnace. It is 40 feet by 4 feet at the tuyeres. Sixty tuyeres, half a foot in diameter, are arranged in three steps, at differences in height of every half a foot in conformation to the slant bottom. The average height of the furnaces is 16 feet from the tuyeres to the top, from which it is charged with the ores and other materials. The gas is made to escape from the furnace through the innumerable holes on the furnace side near its top into the flue. In front of the furnace, an automatically matte tapping forehearth is fitted up. The slag from the forehearth is again permitted to run into a cleaner. The slag flowing out of the cleaner is granulated by water. The daily capacity of the furnace is 283 long tons. The percentage of fuel consumption are 3 per cent. coal and 1 per cent. coke. Blast pressure is 35 mm. of the mercury column.

The contents of the first matte and the first slag.

| | Gold %. | Silver %. | Copper %. |
|---|---|---|---|
| Matte | 0.000674 | 0.01684 | 20.210 |
| Slag | 0.000007 | 0.00036 | 0.358 |

For the fusion of the matte two rectangular furnaces are used, one is 16 feet long and 4 feet wide and the other is 9 feet long and 3.5 feet wide at the tuyeres. The number of tuyeres are respectively twenty and fourteen, and the diameter of all tuyeres is half a foot. The furnaces are 15 feet high above tuyeres. In other respects, they are of the same construction as the ore smelting ones. For each furnace a round matte settler, 12 feet in diameter, is furnished. The concentrated matte is kept in the settler until it is tapped out in order to charge the convertors in a molten condition. The daily capacity of the matte smelting is 874.53 long tons. The rates of fuel required are 4 per cent. coal and 0.5 per cent. coke. The pressure of the blast is 35 mm. of the mercury column.

The contents of the valuable metals in the second matte and slag.

| | Gold %. | Silver %. | Copper %. |
|---|---|---|---|
| Second or rich matte | 0.003010 | 0.5300 | 41.870 |
| Second or rich slag | 0.000018 | 0.0061 | 0.654 |

The rich matte is blown up in Bisbee or barrel convertors for coarse copper. They are 6.5 feet in diameter and 7.5 feet long in outer dimensions. The outside walls are enclosed with chrome brick and the inner lining is made with pulverized silica. It is tapped by means of hydraulic power. For the conveyance of the convertors as well as the copper ladle, a twenty ton electric travelling crane is provided. In 12 hours, one convertor can blow up 16 tons of the rich matte. Of the three convertors, one is in use always in active blowing.

Two No. 12 (the largest size) and two No. 10 Root's blowers are furnished for the pot roasting, ore and matte smelting; and one air compressor for the convertors. The air to be compressed amounts to 3,000 cubic feet per minutes. The pressure of the compressed air is 12 pounds per square inch. Electric motors geared are 320 H.P. for the blowers and 275 H.P. for the convertors.

Two water power electric stations, 5 miles from the mine, supply the power of 600 and 300 k.w. respectively for the mines. Forty-eight electric motors can be counted, among which five are in reserve to spare for emergencies.

The labourers employed are 1013 persons:—miners 242, dressing-hands 44, smelting men 313, porters 163 workmen 682, and coolies 1087.

**Products.**

| | | | Products from smelting. | | |
|---|---|---|---|---|---|
| Year. | Ore. long tons. | Purchased Ore. long tons. | Gold. troy oz. | Silver. troy oz. | Copper. long tons |
| 1904 | 5,596 | — | — | — | 138 |
| 1905 | 11,563 | — | — | — | 246 |
| 1906 | 20,201 | — | — | — | 260 |
| 1907 | 34,164 | 758 | 16.67 | 500.80 | 787 |
| 1908 | 84,141 | 414 | 1,558.40 | 30,615.50 | 1,871.5 |

As regards the rapid progress of the mine, it will suffice to say that all the things that have been described, have been carried on only since two or three years ago. Especially, the uses of the rock drills and boring machines have played the mest important parts.

With the new smelting works, an electric railway, some three miles long has been constructed between the works and the Sukegawa station. When the third electric power station now in construction is completed, electro-refining and other accessory work will be undertaken.

## THE KUNE COPPER MINE.

The Kune mine is in a mountainous region eovered with thick forests, on the left side of the upper course of the Tenryū River, 36 miles north of Hamamatsu station of the Tokaidō Railway.

The mine, it is said, was discovered 170 years ago, its practical operation being planed by several owners in succession, after the Restoration; but it was only ten years ago, that the mine became at all prosperous.

Rich deposits occur intercalated in the sedimentary strata of the Palaeozoic age, consisting of graphite schist and chloride schist. All the strata, having contorted under powerful compression, after their formation, the beds folded so considerably that they were split into forks in the most serious parts. They strike generally 35 degrees and dip to the north-west at 30—60 degrees.

The Okuhi, the most important deposit, forms an irregular massive ore body extending about 1,000 feet with an average width of 45 feet its most dilated part attaining about 100 feet. Several other beds occur in lenticular masses of smaller sizes varying in width from 3 to 25 feet. They are frequently cut off by many faults of indefinite directions; and especially in their lower parts, they are dislocated with little throws on by faults of two or three steps.

The composition of the ore is 4.5 per cent. copper, 42 per cent. iron, 45.0 per cent. sulphur and 4.5 per cent. silica. The best ore contains more than 20 per cent. of copper.

The present mine works are limited to a height of 700 feet above the main adit. The deposits have been approached by three cross cuts of 100 feet to 1,800 feet on the foot wall side, or on the river side, and along the strike, levels are oped at heights of every 50 feet or 100 feet in the foot or hanging wall in the deposit. Winzes are placed at intervals of every 50 or 100 feet as roads for the men as well as for ventilation. Such level is connected by an incline with foot steps for walking. In the Okuhi, chiefly a method of cross work is used. This system is commenced by cutting a level in the middle of the deposit, in order to receive the ore from the winzes afterwards and from suitable points usually 100 feet apart slices are worked out laterally and upward; (it appears to be a common double winged overhand stoping, when the slicing has progressed in the opposite direction from the strike).

On the other hand, in the narrow deposits, up to 25 feet in width, it is divided into two parts along the strike, which are worked laterally in turn. One stope is 7 feet high and 8 feet wide. The deposits are taken out successively upwards.

Lest the roof should fall down, the excavations are temporarily propped up, and soon after square sets are built of logs, above 0.9 feet dia. at the end. In this way, the excavations are packed up with the rubbish produced from the preparatory works and the earth and stones dug from the surface ground.

In the main levels, 12 or 18 lbs. rails are laid in a double track. Iron ore tubs of 2,000 pounds capacity are used. In the picking work, the ore is classified by fixed sieves of 48, 18 and 6 mm. spaces respectively. The finished ore is conveyed to an ore-bin by railways, while the poor ore is heaped upon the open ground where it is leached with the mine water. The water is conducted into a series of precipating tanks, partitioned into narraw canals, they making up a long narrow course of 4,500 feet and gradients of 1:150. The copper is precipitated from the water by scrap iron in the boxes. The contents of the cement copper are 60 per cent. when dried. The ore kept in the ore bins is sent down by two aerial rope tramways to ore bins on the band of the Tenryū River. The ore is sent off in boats to the Tenryū station on the Tōkaidō Railway, whence it is carried away for consumers.

438 labourers are employed:—miners 324, porters 11, coolies 33, spalling and picking men 70.

The products of the copper ore and the cement copper.

| | Copper ore. long tons. | Cement Copper. long tons. |
|---|---|---|
| 1904 | 17,554 | 61 |
| 1905 | 30,330 | 145 |
| 1906 | 34,924 | 211 |
| 1907 | 42,458 | 231 |
| 1908 | 43,018 | 148 |

## THE OGOYA COPPER MINE.

The Ogoya mine is situated in the hilly district, 12 miles south-east from Komatsu, a town on the Hokuriku route. The mine has many branch mines in the vicinity, of which the Gokōji mine is the largest and most prosperous and lies 9 miles north-west of the Ogoya mine. Three champion lodes and smaller branch veins of the Ashio mine type run from the north-west to the south-east in Tertiary and liparite. The width of these is commonly from 2 to 3 feet and the longest vein is 3,500 feet, the present depth of the mine being 630 feet and the tenor of the mined ore 4.5% Cu. The vein is approached by numerous cross cut, 8′ × 8′ in section. One blind shaft of 120 feet depth winds the ore by water balance and the other opens to the air 350 feet in height and is equipped with a hoist directly driven by a 10 H.P. Pelton wheel. There is also one shaft in the Gokōji mine which is 130 feet deep and has a 25 H.P. Lidgerwood hoist. Each haulage level is driven at a vertical height of 100 feet and one winze is commonly made in a distance of 100 feet. The ore wider than one inch is to be mined by weight contract at a price of from £1. 2s. 5d. to £4 per ton according to the tenor of the ore. Thus one man mines about 500 lbs. of ore per shift of 8 hours. The mine water is drained by the levels except in the Gokōji mine in which a 7 H.P. Worthington pump is used.

The ore mined is classified into the richer and the poorer grades, the former is directly smelted and the latter is sized by 25 mm. grizzlies. The undersize of it is sized into over 17 mm. and 17—10 mm. The second size is fed into one coarse jigger of 3 compartments. The first size is picked on two picking-belts, the middling of which after being crushed to 6 mm. by 30 inches Crown roll are sized by 7.0, 4.5, 3.0, and 2 mm. trommels with the undersize of 10 mm. The sized ore is fed into four corresponding jiggers of three or four compartments. The oversize of 25 mm. grizzlies is spalled after washing; the middlings of the spalling are crushed to 25 mm. by a 10″ × 7″ Blake crusher and sized by 17 and 10 mm. trommel; the oversizes of this trommel are picked on two picking tables, and the middlings of the last picking are reduced to 6 mm. by 12″ × 8″ Dodge crusher and the 22 inches dia. Humboldt roll. 17—10 mm. ore is fed into a coarse jigger of three compartments. The undersize of the 10 mm. trommel, the product of the Humboldt's roll, and the richer middlings of all the above jiggers are crushed to 3 mm. by 12 inches dia. roll and are treated in four coarse jiggers after sizing by 7, 4.5, 3 and 2 mm. trommels. The undersize of this 2 mm. trommel and the poorer middling of all the coarse jiggers are crushed to 1.5 mm. by two 3.5′. Huntington mills. These are classified by pointed boxes, the settles of which are treated in 4 bed jiggers and the overflow of which is treated in five Overstrom and three Wilfley tables after condensation by other pointed boxes. All the above machines and 8 inches dia. centrifugal pumps are driven by a 60 H.P. Pelton wheel and 25 H.P. gas engine, there a 40 H.P. oil engine is equipped for spare. The dressing in the Gokōji mine is done by the manual labour which will be replaced by machines of 1,000 tons capacity per month in the near future. The tailings of the fine concentrators are still valuable, so that a Pinder concentrators will be erected to treat them again. The 1—6 mm. fine concentrates are roasted in a Herreshoff roaster of 11 feet 9 inches inside dia., having five shelves, 7.5 long tons capacity and moved by 2 H.P. Pelton. The roast and raw coarser fines are bricked by manual labour and dried in two drying furnaces, then is fed in the smelting furnace, which is a 3 feet 10 inches diameter total jacketed one and has six 4 inches tuyeres. This smelts 40—50 times of the charges which consist of 355 lbs. of briquet, 480 lbs. of raw lump, 25 lbs. of return matte, 281 lbs. of return slag, 207 lbs. Mabuki slag, 124 lbs. limestone and 140 lbs. of coke. The matte produced has 44% copper which is fed into five or six Mabuki hearths in a molten state and converted into blister copper, one Root's No. 4 blower supplies 21—25 mm. blast for the furnace and hearth, it is driven by a 10 H P. Pelton wheel or 20 H.P. oil engine in default of water power. The analyses of ore and products are given as follows:—

| | Cu. % | Fe. % | S. % | $SiO_2$ % | CaO. % | Au % | Ag. % |
|---|---|---|---|---|---|---|---|
| Ore mined | 4.50 | 7.14 | 8.04 | 79.05 | — | — | — |
| Ore dressed | 13.62 | 25.59 | 28.23 | 29.14 | — | — | — |
| Matte | 44.00 | 28.04 | 27.16 | — | — | — | — |
| Slag | 0.37 | 31.12 | 0.65 | 41.45 | 9.46 | — | — |
| Blister copper | 98 70 | — | — | — | — | .00114 | .0153 |

At the end of the year 1908, 856 miners, 136 dressing men, 139 smelting men and 101 other workmen were working at this mine.

The production for the last five years :—

| | | | | |
|---|---|---|---|---|
| 1904 | 15,619 | long tons of ore mined ; | 573 | long tons of blister copper. |
| 1905 | 15,933 | ,, ,, ,, ,, ,, | 620 | ,, ,, ,, ,, ,, |
| 1906 | 17,693 | ,, ,, ,, ,, ,, | 678 | ,, ,, ,, ,, ,, |
| 1907 | 19,328 | ,, ,, ,, ,, ,, | 637 | ,, ,, ,, ,, ,, |
| 1908 | 23,215 | ,, ,, ,, ,, ,, | 685 | ,, ,, ,, ,, ,, |

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## THE YŪSENJI COPPER MINE.

This mine is situated in a very convenient place near the navigable stream of Kakehashi and 5 miles 16 chains east of the town of Komatsu, whence 7 ton locomotives draw several 3 ton cars for the use of the mine. The geology is similar to that of the Ogoya mine. Two paralled veins running north-east are cut by one clay vein striking nearly from the north to the south. The first is 2 feet wide on an average and 2,000 feet long, the second is 2,500 feet long and 3 feet wide and the third is 3 feet wide 1,500 feet long.

The place being only 200 feet or a little more above the sea level, the main shaft was sunk to the depth of 720 feet at present, in which five main levels were driven; being equipped with a 100 H.P. Lidgerwood hoist to the shaft and the first level serving for drainage. The ore is mined by overhand stoping of 6—7 feet height and 12—15 feet sole, a winze being commonly made at every 150 feet and a chute at a distance of 30—50 feet. The richer ore than 5% copper content is separately treated in dressing, the amount of which is about 480 long tons a month containing on an average 6.4% of copper. The other ore (1.57% Cu) is 4,000 long tons per month. The mine water amounts to 35 cubic feet per minute and is pumped up by two 25 H.P. Knowle's pumps at the second level, one 10 H.P. pump at the third level, three 15 H.P. pumps at the fourth level and two 10 H.P. pumps at the fifth level, the pumped up water being used for dressing.

Formerly the mined ore containing about 2% copper was concentrated in dressing to 9% copper. The richer class of the ores is sized by 20, 13 and 5 mm. trommels and the largest is picked on the picking belt, the smallest are treated as the heading and 13—5 mm. ore is treated in coarse jiggers. The oversize of 60 mm. grizzlies of the poor ore is broken by 20″ × 30″ Blake crusher of Marsden & Co. of Leeds, England and subjected to the picking belts with the 30—60 mm. sizes, the middling of which are crushed by 12″ × 6″ and 10″ × 4″ Blake crushers and then by 22″ dia. crushing rolls and 18″ dia. Krom roll to 8 mm. size and treated similarly to the undersize of the 8 mm. trommel. The undersize of 30 mm. trommel is sized by 20, 13, 8, 5 and 2 mm. trommels and treated in eight Harz jiggers, the middlings of which are crushed by four 5′ dia. Huntington mills and after classification by pointed boxes are treated by ten bed jiggers, seven Overstrom tables, two Wilfley tables and one Pinder concentrator. The final tailing is carried to the dump by a 50 H.P. hauling engines along an incline and a 15 H.P. endless rope. Thus 390 long tons of lump of 7.3% Cu, 180 long tons sand of 7.6% Cu and 380 long tons fine of 7.0% Cu are produced a month.

Formerly the headings were smelted without using pyrites then the consumption of coke and limestone was 24% and 4% respectively, but since the beginning of 1909 pyrites are added in the charge, which economizes 60% of the consumption of coke. The fine concentrates are bricked by 15 steel stamps and fed in a smelting charge after being dried by nine drying chambers utilizing the heat of the slag. The smelting furnace is a 3′ by 8′ partial jacket one, having fourteen 4.5 inches dia. tuyeres and smelts on an average during 24 hours 30 long tons of ore, 7 long tons of flue-dust, 7 long tons of pyrite, 19 long tons of limestone and 25 long tons of slag, consuming 4.7 long tons of coke, the blast being 25 mm. There is also one spare furnace of 40 inches diameter which has six 4.5 inches tuyeres. One Roots No. 5 blower of Thwaits Brodford is driven by 25 H.P. motor, the blast being equalized its fluctuations by an air receiver. The matte contains commonly 30% Cu which is converted into 97% Cu blister copper in the Mabuki hearths.

The generating station is situated about 7 miles south-west of the mine, where 450 H.P. McCormic turbine drives a 300 k.w. dynamo of the Shibaura & Co. For the case of the scarcity of the supply of water, there are three 213 k.w. dynamo driven by steam engines. There are four boilers of 540 H.P., six engines of 525 H.P. and twenty six motors of 392 H.P. There were 375 miners, 179 dressing men, 135 metallurgical men and 168 other workmen.

| | The ore mined. long tons. | Copper produced. long tons. |
|---|---|---|
| 1904 (From Sept. to Dec.) | 295 | 6.2 |
| 1905 " " | 10,990 | 200.2 |
| 1906 " " | 18,448 | 416.2 |
| 1907 " " | 29,928 | 429.1 |
| 1908 " " | 44,990 | 610.5 |

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## THE ŌMORI COPPER MINE.

The mine is situated about 3.5 miles west from the town of Ōmori in Shimane prefecture, and it is over 7 miles from the port of Yunotsu where the steamer calls on which sails to Ōsaka. Hence by the sea the mine communicates with different markets in Japan, and the road which connects the mine and the port is tolerably level.

The principal rocks in this mine are enstatite porphyrite and Tertiary rocks. There are five veins which have been produced by the filling of the fissures with mineral solutions and even now in the deeper level, there is a hot spring so that the temperature in the mine is tolerably high. The dip of the veins varies from 80° to 70° north, with from 10 inches to 3 feet width and ore exists in bands in the veins, its average width being 7 inches, but it sometimes swells up to 6 feet.

The mining method is commonly used one in metal mines, that is, levels are driven along the veins and the veins are then worked upward or downward from the levels according to convenience. The excavated places are packed with the rubbish. The ore in tubs is wound to the main level by a winding engine and carried out to the dressing mill by the labourers. At present the depth of this mine is nearly 500 feet from the adit while mine water is lifted to the adit by pumps, its volume being from 29.5 to 39.3 cubic feet per minute.

Machines used in mining :—

| | Number of machines. | Length of stroke. | Diameter of plunger. |
|---|---|---|---|
| Winding | 2 | —— | —— |
| Duplex compound sinking pump | 4 | 6″ | 5″ |
| Triple single settle pump | 2 | 10″ | 8″ |
| Cornish pump | 4 | 2′.1″ | 8″ |

The raw ores, which are carried out from the mine, are classified into four kinds; that is to say, lumps, grains, sand and rubbish. The former two are subjected to spalling and cobbing, the sands are washed and sized with $\frac{3}{8}$ inch trommels, the oversize is fed to the picking belt conveyer and the undersizes are sieved into three classes to feed the jigs. The tailings from the spalling and picking table are crushed by mills or rolls and are then subject to the jig.

Average composition of dressed ore:—

| Cu. in % | Au in one long tons. | Ag in one long tons. |
|---|---|---|
| 7.75 | 0.53 oz. | 19.75 oz. |

The furnace is charged with the raw ore and briquets, although they are small in amount, with limestone and Mabuki slag as fluxes. The matte produced being roasted, is subjected to the Mabuki process to get blister copper which contains gold and silver.

There are four steam engines of various types, nine electric motors and six Pelton water wheels, their power being 431, 255 and 185 H.P. respectively.

The number of labourers is 675 in total, that is, in mining 293 men and 47 women; in smelting 47 men and 25 women; in dressing 72 men and 106 women, and in the workshop 85 men.

Annual production for the last five years:—

| | Raw ore. long tons. | Dressed ore. long tons. | Blister copper. long tons. |
|---|---|---|---|
| 1904 | 25,206.2 | 2,061.2 | 100.14 |
| 1905 | 20,838.8 | 2,470.3 | 125.71 |
| 1906 | 20,534.8 | 4,083.6 | 229.24 |
| 1907 | 21,693.8 | 4,275.6 | 277.36 |
| 1908 | 22,402.3 | 4,706.8 | 325.82 |

Various metals in blister copper:—

| | Au in troy oz. | Ag. in troy oz. | Cu. in long tons. | Pb. in. long tons. |
|---|---|---|---|---|
| 1904 | 790.238 | 47,233.78 | 94.91 | 1.8033 |

| | | | | |
|---|---|---|---|---|
| 1905 | 1,032.117 | 45,461.07 | 120.15 | 2.1807 |
| 1906 | 761.217 | 56,863.55 | 220.65 | 3.1241 |
| 1907 | 1,334.313 | 73,580.60 | 266.56 | 3.8868 |
| 1908 | 1,689.600 | 96,153.60 | 314.17 | 4.0918 |

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## THE YOSHIOKA COPPER MINE.

The Yoshioka mine is situated in the province of Bitchū, 24 miles north-west of Tadai, a terminal point of the Chūgoku line, the Sanyō Railway.

This mine region is occupied by the Paleozoic clayslate and graywacke sandstone, those rocks having been metamorphosed in certain parts to hornfels by the influence of the porphyrite intruded in the southern vicinity. In these sedimentary rocks, the deposits belong to fissure veins, filled with chalcopyrite, pyrrhotite, iron pyrite and calcite and also rarely with hedenbergite and quartz. There are many veins, of which some ten are most important. They may be divided into two groups, namely those striking south-north and dipping at 70 degrees and those striking east-west and dipping at some 55 degrees. The veins swell and pinch, so that the ore bodies are found in lenses.

In the Sasase district, the "Yokomono," an irregular deposit, which is considered to be a metasomatic replacement, is cut by a true fissure vein. Minerals in both deposits are chalcopyrite, iron pyrites and zincblende.

The contents of the ore are on an average a trace of gold, 0.006 per cent. silver and 4—6 per cent. copper. For the mining works, one winding engine and one pump are now used. At present, there are five levels and from the third level, a shaft, 250 feet deep has been sunk; at that shaft a Lidgerwood electric double drum winding engine is equipped, as in the fifth level. A Deming's single acting force pump is provided for the drainage of the workings below the third level.

The mine stuff is sorted into rich ore and poor ore. The former is roughly classified by hand into over and below 60 mm. ores; and the first size is spalled; the production being concentrates, middlings, pyrite and rubbish; the middlings are sent to the dressing house, while the second size passes a 36 mm. hand sieve; the oversize being picked out to concentrates and rubbish; and the undersize is sent off directly or through the dressing house to the smelting works according to its richness. The latter passes successively a grate, spallers and cobber's hands, a breaker, a series of trommels, picking tables or picking belt and finally enters the jiggers and the concentrators.

The products of the preceding operations are spalled and picked headings, that from jiggars and fine concentrates. The monthly output of the concentrates is 1,500 long tons from the original mine stuff of some 7,000 long tons.

The dressing mill is as follows:—Three cast iron-grates, 6 feet × 6 feet, with 60 mm. polygonal meshes; one Blake breaker, 16 inches × 10 inches, of 38 long tons capacity per day; one Dodge breaker, 12 inches × 7 inches, of 40 long tons capacity; one pair of rolls, 20 inches × 20 inches, of 40 long tons capacity per day; two Huntington mills of 5 feet dia., of 50 long tons capacity; fourteen trommel; one flat sieve of 1.5 and 1 mm. meshes; two pointed boxes; two picking belts made of hemp-palm, one 15 in. × 53.5 feet and other 18 in. × 53.5 feet; five coarse jiggers and eleven bed jiggers; five Wilfley; one Pinder and one Cammett concentrators, their capacities being respectively some 50 long tons, 9 long tons and 3 long tons of dried pulp per day; one triple lifting pump of 36 cubic feet capacity per minute; one 1,663 feet single wire tramway and one incline operated by water balance.

Smelting is carried on by two processes namely the smelting of the raw ore and the Mabuki or the matte smelting.

The blast furnace is of a rectangular section rounded at the corners, 3 feet wide 6 feet long and 8 feet high above the tuyeres. The water jacket is provided for height of 8 feet (6 feet above and 2 feet below the tuyeres). Ten tuyeres, 4 inches in diameter, are fitted up. The forehearth in a similar form is 3 feet wide, 5 feet long and 2.5 feet deep, lined with bricks inside and covered with clay upon them. The second furnace is 3.5 feet wide and 8 feet long at the tuyeres and 4 feet wide and 8.5 feet long at the level of the charging floor. It is provided with twelve tuyeres, 4.5 inches in diameter. It has a water jacket for a height of 8 feet. The forehearth is 6 feet in diameter. The daily capacities of the furnaces are respectively 50 to 70 long tons and 90 to 12 long tons with the products of

7 to 8 per cent. of matte, in which 30 to 50 per cent. of copper is contained. The blast for Mabuki is commonly furnished by two No. 7 Root's blowers of from 35 to 40 mm. pressure.

The Mabuki hearth is a flat conical hearth made in the ground, 3 feet in the uppermost diameter, 2 feet in the lowest diameter and 1.5 feet deep. Ten of such hearths are provided among them, four or five are usually used. The capacity of each in one operation is from 5 to 6 long tons of the matte.

The annual amount of the ore smelted is about 16,200 to 20,400 long tons, of which the Yoshioka ore is 15,000 to 18,000 long tons, the balance coming from the branch mines and others. Besides them, "Dōkin" (Iron pyrites) and old slags are melted.

The production of black coppers is some 900 long tons per year. The fineness of the copper is 97—98.5% copper, 0.22—0.27% silver and a trace—0.0005% gold.

Fine ore and flue dust are treated partly by pot-roasting, partly by briquetting and roasting. For these purposes, one roasting pot of 64 cubic feet capacity and two batteries of fine stamps are employed.

One 300 H.P. Francis horizontal double turbine; one 225 k.w. and 3,000 volt, magnetic field rotary, high potential alternating current dynamo; ten three-phase induction motors, one 100 H.P. for blower, one 5 H.P. and one 30 H.P. for pumping, one 30 H.P. and four 25 H.P. for dressing, one 30 H.P. for the workshop and one 5 H.P. for briquet stamping are now in use.

The labourers employed are 1,273 persons:—miners 546, dressing hands 124, smelters 129, porters 318, engine drivers 3, workmen 46, superintendence and other business 45 and miscellaneous 62.

**Products.**

| | Ore. long tons. | Purchased. Ore long tons. | Gold. troy oz. | Silver. troy oz. | Copper. long tons |
|---|---|---|---|---|---|
| 1904 | 9,096 | — | — | 54,921<br>— | 620<br>— |
| 1905 | 12,513 | — | — | 70,264<br>— | 843<br>— |
| 1906 | 12,355 | 876 | — | 56,080<br>2,909* | 715<br>36* |
| 1907 | 10,886 | 1,905 | 64 | 54,285<br>7,134* | 695<br>151* |
| 1908 | 12,642 | 483 | 139 | 59,411<br>1,179* | 744<br>34* |

* Show the products from the purchased ore.

## THE OBIYE COPPER MINE.

One who travels through the Sanyō railway will see to the south side of the railway a chimney, projecting on a hill amidst rice fields 2⅝ miles east of the station of Kurashiki. This is the Obiye mine, which is possessed by Sakamoto & Co.

The geology is paleozoic slate in which is intruded an irregular boss of quartz-porphyry, varying in width from 10 feet to 50 feet. Veins of chalcopyrite exist in the slate, enclosed by the quartz-porphyry in such a manner that the mining is carried on separately for each division. The description of the veins may be seen from the annexed table:—

| Name of division. | Position in the claim. | Strike. | Average dip. | Width. |
|---|---|---|---|---|
| Toba. | At the north-east corner. | 100°-80° | 80° W. but sometimes vertical or in the opposite direction. | Average 1 feet sometimes over 10 feet. |
| Saruhiki. | At the centre. | 120°-90° | 70° S. | 1 foot on average. |
| Tanaka. | Between above two. | 90° | 80° S. | Ore is soft but existence is sure. |
| Kurosaki. | At the south-seat corner. | 180° | 60° W. | Ore exists in lenses, one of which is 8 feet in width and 50 feet long. |
| Kanasai. | | 100°-80° | Ditto to Toba. | Ditto to Toba. |

| Name of division. | The present depth of mining. | The present elongation of the mining along the strike. | Copper content in the ore. | Silver content in the ore. |
|---|---|---|---|---|
| Toba. | 850 feet. | 2,500 feet | 8.5 % | 0.013 % |
| Saruhiki. | 600 feet. | 1,000 ,, | 7.0 ,, | 0.016 ,, |
| Tanaka. | 300 feet. | 200 ,, | 9.0 ,, | 0.017 ,, |
| Kurosaki. | 400 feet. | 1,000 ,, | 8.0 ,, | 0.025 ,, |
| Kanasai. | 700 feet. | 1,500 ,, | 8.0 ,, | 0.013 ,, |

Among them, the Toba and the Kanasai are the champion lodes; and the Saruhiki gives a promise of being the most prosperous in future, though the extension in the actual mining is as yet small. There are four shafts for each vein. except the Tanaka. The Toba shaft is equipped with a 30 H.P. electric hoist and has in reserve for contingencies a 55 H.P. steam hauling engine. The Kanasai shaft is worked by a 55 H.P. steam hoist. A 35 H.P. steam engine hoist is placed at the Saruhiki and the Kurosaki shaft respectively. There are nine levels at Toba, five at Saruhiki, four at Kurosaki and three at Kanasai. The first and the last division are connected. It is intended to connect Toba and Saruhiki by driving a level from the west end of the seventh level in Toda with rock drills. For the level driving, eight of the Little Giant O.D. type rock drills are in operation, one half of them being for reserve use. They are moved by a 50 H.P. Ingersoll-Rand's air compressor. The ore is excavated by overhand stoping in which 8 feet is taken as a standard height and 12 feet for sole. Pumping is commonly done by winding buckets, only in the case of Toba a 20 H.P. Worthington is used.

The ore mined is first treated by hand dressing at rock houses near each shaft. The ore larger than 3″ is sledged into 2″ and spalled; the middling of which is partly smelted and partly stored for future treatment at the times of the development of the dressing. That smaller than 3″ is passed through $1\frac{1}{4}$″ and $\frac{3}{8}$″ grizzlies, the oversizes of which are picked after being washed by water The undersizes of the $\frac{3}{8}$″ grizzlies and the middling of the pickings are conveyed to the machine dressing plant at Saruhiki where they are crushed and sized with grizzlies, trommels and 12″ × 4″ Dodge crusher into six kinds i.e, larger than $\frac{5}{16}$″, $\frac{5}{16}$″—$\frac{1}{4}$″, $\frac{1}{4}$″—$\frac{3}{16}$″, $\frac{3}{16}$″——$\frac{1}{8}$″, $\frac{1}{8}$″—$\frac{1}{16}$″ and smaller than $\frac{1}{16}$″. The former five are fed into five corresponding bed jiggers, the middlings of which are again treated in another bed jigger. The fine smaller than $\frac{1}{16}$″ are treated on two percussion tables and then in two buddles after classification by pointed boxes. . All the machinery is driven by a 40 H.P. motor and a 16 H.P. steam engine.

Up to the end of 1908, the smelting was carried on at this mine, but is now done at the island of Inu which is situated at the mouth of the Kojima Bay and is 2.5 miles in circuit. This plant was erected at a cost of £20,000 in the middle of Feb. 1909. Besides the ores from the company's own mines, cupriferous pyrite from Chūgoku and the provinces of Kii and Awa are also brought here by junks. The island has so good a harbour that these ships are able to lay at anchor on the coast, it has also an abundance of water both for drinking and other purposes. All stuffs are raised by a 90 H.P. compound hauling engine.

The ore smelting furnace is from Allis-Chalmer Milwaukee in the U. S. and is 44″ by 140″ at the tuyeres and has eighteen 6" dia. tuyeres, the charge consists for example of 1,100 lbs. of Obiye richer ore (containing 6.5% Cu), 940 Obiye poorer ore (containing 1.4% Cu), 350 lbs. purchased ore, 1,510 lbs. pyrite cinder, 700 lbs. of refinery slag and 400 lbs. of limestone which has 48.2% CaO deducing self-fluxing part. The charge is fed from both sides by shovels

In this furnace 3,050 long tons of ore and 480 long tons of refining slag are to the treated a month, with blast of 25—30 mm. of mercurial column. The content of the copper in the total charge is on tho average about 2.3% and that of the matte produced is from 16 to 20% (averaging 18% Cu).

The matte which contains 35% sulphur is after crushing to 3″ size roasted in stalls to 10—12% sulphur. The roasted matte is resmelted with 13% of silicious flux, i.e. Obiye poorer ore, in 3′ — 10″ dia. brick furnace. The capacity of the furnace is 27 long tons, using 20—25 mm. blast. The matte produced contains 50—65% Cu which collects in the bottom of one of the two forehearths in which bessemerizing is operated. The blister copper contains about 97 to 98% copper and 0.14—0.17% of silver, which is shipped to the Ōsaka electro refining company or to the Mitsubishi Ōsaka Refinery in order to extract the silver. It is intended to build one more concentration furnace of the same type. An American Root's No. 7 blower is in action for all the furnaces revolving at 100 revolutions per minute, driven by an Allis-Chalmer's Corliss engine of 160 H.P. One Deane's pump of 12″ dia. water cylinder and 12″ stroke is acting for pumping up the iacket water to a head of 30 feet. As to accessory work, there are 50 Beehive coke ovens of 11 tons capacity, coal from the collieries of Miike, Man-noura or Asahi being used; and bricks are made by using the waste heat of the coke ovens A Corliss engine is used for the generation of electricity and moves 100 k.w. D. C. dynamos of Allis-Chalmer.

The number of workmen at the end of 1908, were 538 in mining, 154 in dressing, 237 in smelting and 39 in miscellaneous works.

The productions for five years from 1904 to 1908 are as follows:—

| Year. | Mined ore. long tons. | Copper. long tons. |
|---|---|---|
| 1904 | 11,084 | 502.4 |
| 1905 | 33,739 | 548.0 |
| 1906 | 56,011 | 657.4 |
| 1907 | 61,631 | 696.4 |
| 1908 | 47,083 | 736.4 |

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## THE BESSHI COPPER MINE.

This is a champion among the copper mines of the so-called bed type in Japan. It has been possessed by the Sumitomo since its discovery in 1690. From that year to the end of 1909 the total copper production amounted to 1,922,560 long tons, still the ore reserve left is said to be beyond estimate. The mine is situated on the watershed range of Shikoku, which is from 4,000 to 3,000 feet above the sea level. It is connected with Niihama by railway. From Niihama, several steamers of 67,756 total tonnage sail to Onomichi, Ōsaka or the islet of Shisakajima; the last is at present used for the smelting plant.

General geology is chlorite, graphite and piedmontite schist of which the former two are mostly developed. Quartz schist runs along both sides of the deposit which in same case transits into sericite schist or piedmontite schist. Besides them amphybole schist, eklogite and also several dykes of serpentine containing cromite crop out at some distance from the deposit on the hanging wall side. A bed of cupriferous iron pyrite runs between the above rocks, striking at 120°, dipping at 45° northward in the upper level and at 60° in the lower horizon. The bed is over 5,000 feet long, 2—30 feet wide and the present deepest part is 2,150 feet deep along the dip. In the bed two swells seem to course from the upper west part to the lower east corner, sloping at about 45°. There are several step faults in the eastern part. The ore may be classified into three kinds i.e. 1° Massive pyrite, containing about 3% Cu, 2% $SiO_2$ 2° Banded ore with the country-rock containing 4% Cu, 30% $SiO_2$ 3° enriched ore. The average tenor of the ore during the last three months is 3.8% copper, 33.3% sulphur and 35.3% iron.

It was formerly worked from the upper horizon seeking after the rich part. A French engineer designed in the year of 1874 a shaft. It was sunk at 49° inclination along the footwall of the bed from a part of outcrops on the south side of the range. A 300 H.P. steam hoisting engine was set up there, fit for winding up from a depth of 3,000 ft. The third adit was driven in a level 2,459 feet above the sea level which is in the same horizon as the ninth level. It is 5,936 feet long and 11′ by 10′ large, and also serves as a drainage level. There is in addition one drainage level which is 3,560 feet long. This level is in same level as the fourth level. Besides these, one more adit of 13′ × 10′ will be started in the near future from Hateba, the end station of the lower railway. This is estimated to be 15,865 feet long and will be connected with the eighth level by a shaft about 1877 feet deep, which will be a 16′—6″ dia. brick-walled one and started from a point in the hanging wall 550′ apart from the bed. The compressor for rock drills is going to be set at Hateba. This will be perhaps the last adit of this mine and after the completion of this work with that of motive power, the production per day will be increased to over 1,000 long tons. The tenth level is deepest one which is in 1,721 feet deep. Each level is 7′ × 7′ size, has a one-hundredth gradient and one line of 18 lbs. rails of 20½″ gauge. The total elongation of the chief levels is 9 miles 70 chains, that of the rail is about 13 miles and that of the inclined shafts except the above mentioned ones is about 1 mile. At every 30 feet a chute is made and at the every 10 chutes one winze; and overhand-stoping is adopted as the method of mining, its breast being 7 feet high, the sole 15 feet and its width from 3 feet to the width of the deposit. Boring is chiefly done by hand, yet rock drills are applied in excavation of broad beds and level drivings. There are fourteen Schram $3\frac{1}{4}''$ rock drills, fifteen Leyner's $2\frac{5}{16}''$ drills and ten $1\frac{3}{16}''$ hand drills of Pneumatic company, driven by three Rands, three water Leyner, one Schram compressors of a total of 750 H.P. Blasting was first adopted among us in this mine in 1867 when gun-powder was used with fuses made of a sort of bamboo. Ores excavated from uper four levels are brought to the rock-house at the mouth of the first adit in ox cars. Ores from lower levels than the 4th are collected in the ninth level from whence they are brought to a rock house near the third cross cut by electric cars. The hauling engines at the eighth level is moved by a 38 H.P. compressed air, which will be replaced by 120 H.P. electric hoist in the near future. The smaller windlass will not need description. The electric locomotives are 3 ton Westing-house ones which run on 20 lbs. rails. As to timbering they use chiefly cypress or pine. There is nothing particular as to ventilation and illumination. All the water is at present drained through the third adit and the lower part is drained by a 5 H.P. plunger sinking pump and 5 H.P. Knowle's pump, their plungers are made from phosphor-bronze on account of its high acidity, while the plungers last only one month's working of one time at every two or three days. The total amonnt of the mine water is only 40 cubic feet per minute, but it contains about 0.02% copper so that cement copper is taken from it. The mine water from the third adit is induced to ninety decopperization wooden boxes each 8 feet in length, 3 feet width and 1 foot deep, which contain scrap iron and their slope is at the rate of 1 : 5.5. The average production of the precipitate is 35 tons per month which contains 50% Cu. The water which has passed through these boxes is conducted by launder to another plant about 1,900 feet below which is made up of one hundred and fifty-two decopperization boxes each 12 feet in length, 8 feet in width and 4 feet 6 inches deep, sloping at $\frac{1}{44}$. These boxes are arranged in four series, in each of which the water flows up and down. In this case scap iron and coke are used as the precipitants, the former consumption being 23% of the precipitate produced. The precipitate taken is on the average fifty tons a month which contains 8% copper. The coke, in which the precipitate is absorbed, is produced to a amount of 200 tons per month which has 1% copper. All these products are sent to the smelting works at Shisakajima. The water after the above treatment is conducted to the sea by a ditch along the ore transporting railway.

The nature of these ores makes the dressing unsuitable so that merely sizing and hand separation are done in the rock houses. There are two rock houses at Kadoishiwara and Tōnaru, the fromer being situated at the mouth of the first adit and the latter at that of the third adit, but after 1911 the whole ore will be dressed in the latter. In Kadoishiwara, about 200 long tons of the ore are treated manually from which 10% rubbish, 70% lump and 20% smalls are produced.

The Tōnaru rock house equipment consists of grizzlies, 1′ × 2′ Blake crusher, belt conveyers, etc., 50 H.P. motor being used as motive power. In this house about 450 tons are treated from which about an equal ratio of lump, fines and rubbish are produced.

The dressed ore from Kadoishiwara is carried by a 3 miles 33 chains long railway along the side of the steep mountain to Ishigasanjyō which is 2,762 feet above the sea level, the locamotive having 10 tons weight and 12 tons tractive force. Two courses of Haldy wire rope are place from Ishigasanjyō to Hateba, an end station of the lower railway which is situated 518 feet above the sea level. The ore from Tōnaru is conveyed by a Bleichbert double rope system aerial tramway to Kuroishi, a station on the lower railway which is situated 403 feet above the sea level. The lower railway is 6 miles 40 chains long. Seven locomotives of 8 miles velocity per hour and 35 tons tractive force run on this line. All these railway and aerial tramways were completed in June 1893 while up to that time transportation has been done by tubs drawn by oxen for a run of 18 miles. At Niihama the ore is shipped in Japanese boats of 30 tons each which are conveyed in a series of 13—15 boats by a tow boat of 123 tonnage to Shisakajima. There are 81 Japanese boats and three tow boats We shall here describe about the source of power, etc., except the matters concerning metallurgy, which will be treated later on as it is operated independently from the mining, etc. Besides the engine mentioned of the main shaft at the mine there are four Lancashire boilers of 21′ 6″ length and 8′ 3″ diameter; one 8 feet dia. 75. H.P. Pelton wheel drives a compressor at Tōnaru. The other machines are driven by electricity which is generated at four stations,—Two stand at Niihama, one Hateba and one at Otoshi, which is situated between Tōnaru and Hateba, in the three former electricity is generated by a steam engine and the last by a Pelton wheel. The specifications of the machines and their equipment may be seen from following table :—

| Name of the stations. | Dynamos. Number. | Kilowatt. | Voltage. |
|---|---|---|---|
| **Niihama No. 1 generating station** | 2. | 180 | 11,000 |
| **Niihama No. 2 generating station** | 1. | 110 | 3,300 |
| **Hateba generating station** | 1. | 110 | 3,300 |
| **Otoshi generating station** | 1. | 110 | 3,300 |

Besides these, there are at the Niihama workshop two Cornish boilers of 25′ length and 5′ 6″ diameter and one 90 H.P. non-condensing engine and one 90 H.P. Schram's compressor. In the near future two 750 k.w. turbo-generators will be put into active service. The steam for them will be generated by four Heine's water tube boilers of 170 lbs. pressure per square inch. The proprietors are also attempting to set up a 6,000 H.P. generator at Ishigasanjyō which has 2,000 feet head and the water supply for power will be taken the ravines. There are 2,185 persons employed in the mining department.

Beside at Niihama, 1,922 men and 103 women are employed in workshops, etc. There are also 121 persons at the Nishinokawa branch mine; ores mined are as follows:—

| Year. | Besshi mine long tons. | Nishinokawa branch mine long tons. | Total. long tons. |
|---|---|---|---|
| 1904 | 132,974 | 2,903 | 133,877 |
| 1905 | 122,211 | 2,130 | 124,341 |
| 1906 | 131,017 | 2,224 | 134,241 |
| 1907 | 164,344 | 3,300 | 167,644 |
| 1908 | 192,634 | 2,661 | 196,243 |

The smelting plant at Shisakajima was erected at the end of 1904 at a cost £253,750. The isles consists of four small ones situated 9.5 knots off the coast of Niihama, having 4,800 inhabitants who lead a most comfortable life, as the Sumitomo makes every endeavour for the convenience of the labourers such as amusement-clubs, hospitals, schools, etc. They have the intention to treat the ore by pyrite smelting and then bessermerize the matte by convertors and make sulphuric acid. They are now examining the pyritic smelting and pot roasting. Both are said to have good results in spite of the unsuitable construction of the furnace for pyrite smelting as to the tuyere opening and the height of the charge. By pot-roasting, the cost of the works may be lessened very much more than by briquetting by the brick making machine and in the near future one more ore smelting furnace will be fitted up for pyritic smelting. Fine ore from the mine is again sized by half inch grizzlies near the ore landing place of Shisakajima. Fines larger than half-inch are treated like lump ore, i.e. they are party roasted and partly directly smelted in the blast furnaces, a 90 H.P. hauling engines of Robey & Co. carries the ore to the roasting plant, etc.

The roasting plant is placed at the north-east part of the island

and covers an area of about 180,000 square feet which amounts to about two-thirds of the total plant area. There are 278 stalls of 30—37 long tons capacity arranged in steps along the slope of a hill from 42 feet high level above the sea to 130 feet high level, thus the effect presents a castle-like appearance at a distance. There are also thirty stalls in another place for use in case of emergencies. They are constructed with slag-brick and stand back to back, having a common flue in the centre line; all of which lead to a 212 feet high, 14′ 6″ dia. chimney of brick construction placed on a level 145 feet above the sea level. The ore is roasted in them to 10% S in 40 days. Roasts from the stalls, placed above 42 feet high level, are brought to the ore bins at that level by self-acting planes, and in those bins the fines and lumps are separated. The former are used in briquet making. 20% of this and the finest raw ore are mixed with flue dust from ore and first matte smelting and then briqueted into common brick size by two or three common brick making machines driven by 20 H.P. compound-wound motor. This machine has two stamps which drop 24 times per minute and has a capacity of 56 long tons per day. The briquets are smelted in a pyritic-smelting furnace, after being dried by the waste heat of the slag from the ore smelting furnace. Pot roasting was started in August 1908. One pot holds 5 long tons of fine, i.e. that amount can be put in it, but commonly it is operated at 70—80% of its full capacity. At first the ignition was performed with fine coke, while now it is done by hot slag-bricks. One operation consists of four charges the blast being 45 mm. at the last stage and it takes about eight hours. The breaking of the sintered mass is performed by throwing the mass from the pot, which is kept 6 feet above the ground, upon two cast iron domes. The lump produced is 80—90% of the product and the sulphur content is decreased to 14% from 30 sulphur in the original charge.

At present one third of total ore is subjected to pyritic smelting and the remaining part is treated in reduction smelting, two or three in four blast furnaces are used for reduction smelting. These blast furnaces are of the same dimensions, they are rectangular water jacketed ones, 16 feet × 3.3 feet at tuyeres, having 12 back side tuyeres and 10 front tuyeres of 4 inches diameter. They are arranged in one line having long sides in same line; thus tapping is performed from the middle part of the long front side, the bottom of the furnace body sloping to that point at a rate of $\frac{1}{32}$. The charge is done by shovels from only one long side and three 2.97 feet diameter sheet iron flues run up above the charge floor and discharge the waste-gas into a horizonta lcommon flue running in the centre line of the furnaces. Each furnace is also provided with one more flue of the same construction which is to be used only in the case of blowing in or out. The chimney is 204 feet high and 13 feet 10 inches in diameter at the top and is not on a level 42 feet above the sea level. This chimney discharges gases from the matte smelting, bessemerizing and refining furnaces besides the ore smelting one. The matte from the ore smelting furnace flows through the jacketed spout into corresponding 10 feet dia. forehearth. All the jackets are of steel construction, only the tap jacket is made of copper, bronze or cast iron. The water for the jackets is taken from the sea by a Riedler double acting forcing pump, besides which there is one Gwynnes' centrifugal pump. The sea water pumped up is kept in a reservoir of 27,827 cubic feet capacity from which it is delivered to all the furnaces of ore and matte smelting.

(a) Reduction smelting:—The charge of reduction smelting consists of 4,750 lbs. roasted ore, 330—660 lbs. bripuet of raw fines, 330—660 lbs. bricks of flue dust, 500—830 lbs. cupola slag, 330—415 lbs. silicious flux and 620—785 lbs. coke, sometimes cement copper of poor copper content being added to it. The silicious flux is gneiss brought from an island in the Inland Sea and its composition is 6.92% $Fe_2O_3$, 5.88% $Al_2O_3$ and 83.14% $SiO_2$. The capacity of one furnace in this smelting work is about 200 tons per 24 hours, using 0.8 lbs. of blast per square inch. There are seven Thwait-Roots No. 7 blowers, working at 300 revolutions per minute. They serve too for the blast of the matte smelting and are driven by a 320 H.P. Corliss engine. The slag from this smelting is composed by 36% $SiO_2$, 7% $Al_2O_3$, 47% FeO and 0.335% Cu. It flows out of a spout in the upper level of the forehearth whence it is carried on trucks to the sea shore one part of which is conveyed to the dump after utilizing its heat, another part is made into slag brick by covering them with straw ash after casting them into bricks. The matte is tapped eight times a day from two tap holes in the bottom of the forehearth to a multitude of sand moulds made in the beds where they are broken by hammers after cooling and are conveyed to the matte roasting plant. The matte has 28% Cu.

(b) Pyrite smelting:—The first matte from pyrite smelting contains only 13% copper, so that it is to be smelted again pyritically into a second matte of about 26% Cu before being subjected to matte roasting with the first matte from reduction smelting. The pyrite smelting is at present performed in the same furnaces as in reduction smelting, so that the oxidation in the furnaces is insufficient, nevertheless the cost of working to produce a matte of the same tenor is cheaper than the reduction smelting. Thus it is the intention to replace the latter by the former.

The charge of pyrite smelting for ore is made up from 2,500 lbs. raw ore, 1,650 lbs. of raw briquets. 250 lbs. of the first matte of pyrite smelting, 500—830 lbs. of cupola slag, 250 lbs. limestone and 165—290 lbs. coke. The capacity of the furnace in this case is 150 long tons of raw ore, using 10 lbs. pressure blast. The first matte assays 12% Cu and the slag in this case contains 35% $SiO_2$ 4% $Al_2O_3$, 45% FeO and 0.2% Cu.

The charge of matte smelting is composed of 2,500 lbs. of first matte, 165—330 lbs. Atebuki slag, 165 lbs. pot-sinter, 500—830 lbs. cupola slag, 580—660 silicious flux, 125—165 lbs. limestone and 165—200 lbs. coke. On this occasion the furnace smelts 110 long tons of the raw matte with 1 lbs. blast per square inch, producing 27% Cu. matte and slag containing 0.4% Cu, 32% $SiO_2$, 5 FeO. The limestone in the charge is also shipped to this place from an island in the Inland Sea and its analysis is 2.02% $Fe_2O_3$, 1.26% $SiO_2$, 0.52% $Al_2O_3$ and 53.73% CaO.

Matte roasting:—There are fifty-nine stalls of a similar construction to those of ore roasting; they are built in a level 145 feet above the sea level, the waste-gas from which is delivered in the same chimney as the ore roasting, they differ from the ore roasting stalls in having four ignition holes arranged in two steps. Two ignition holes of the upper layer are first fired and seven days after that time the holes in the lower parts are ignited. The time for one operation is about three weeks. The roasted matte contains 10% S which is to be smelted again in cupolas.

Matte smelting:—There are four cupolas of the jacket and portable crucible type of which two or three are in working and the other in repair. They are 3 feet dia. at the tuyeres and have eight tuyeres of 3 inches dia. To each cupola, two reverberatory forehearths are equipped into which molten matte is directly tapped and in which converting or Atebuki is practiced. The reverberatories are 9 feet 1½ inches long, 6 feet 7½ inches wide at the widest part inside the hearth and have two 1¼ inches dia tuyeres. The rich matte contains 64 % Cu. The slag is returned to the ore smelting. The matte is tapped 7—11 times a day; as soon as it enters the reverberatories, a blast up to 15 lbs. pressure is employed and the floating slag is skimmed off after about one hour; when no more slag yields and bubbles issue from the surface, the blast is stopped and the temperature of the hearth is raised by adding a new charge of coal in the fire grate; 30 minutes after this time, blister copper is tapped from the bottom which is cast into molds on revolving plate. 9 long tons of rich matte are treated in this reverberatory for 18 hours. The blister copper contains 98.76 % Cu. The blower for Atebuki is one Riedler's horizontal compound blowing engine which delivers 6,452 cubic feet of blast at 72 revolutions per minute, strokes of 42 inches and the blast can be raised to 15 lbs.

Besides the blister copper from the above mentioned, that from the Nishinokawa branch mine is also refined in this plant. There are two reverberatories (one is commonly in use) for this purpose. It has a 14.5′ × 8′ oval hearth and capacity of 15 long tons per operation. The refined copper contains 99.7—99.9% copper. They partly go abroad through Kōbe and partly to the Sumitomo rolling mill at Ōsaka, where they are made into plate, bar or wire

There are twenty-six Haldy's coke-ovens of 7.4 long tons each and 80 H.P. electric coke pusher. The coal is from the Miike and Karatsu, and 68% of the coke is produced from the mixture of the coals, the gas being used in boiler heating.

There are seven Lancashire boilers of 7 feet dia. and 28 feet long. Besides the previously mentioned engine, the chief ones for other purposes are as follows:—

| Number. | H.P. | Engine. | Dynamo. | Object. |
|---|---|---|---|---|
| 2. | 25. | General Electric & Co. non-condensing dynamo engine. | General Electric's D. C. Compound 220 V. | Lighting. |
| 2. | 100. | Intorle & Seymour & Co. tandem system. | Bullcock & Co. D. C. Compound 220 V. | Miscellaneous. |

The number of labourers at the end of 1908 was 1,380 persons

The production of five years are:—

| | | | |
|---|---|---|---|
| 1904 | 9,443 | long tons of refined copper. | |
| 1905 | 5,001 | " | " |
| 1906 | 5,459 | " | " |
| 1907 | 5,347 | " | " |
| 1908 | 5,173 | " | " |

## THE HIBIRA COPPER MINE.

The Hibira mine is situated not far from the town of Nobeoka, in Miyazaki Prefecture, 34 miles from the small port of Hososhima; whence goods, that are shipped from Osaka, can be carted to the mine.

Four important beds of cupriferous pyrite are intercalated in the layers of clay slate and graywacke sandstone of the lower Paleozoic formation. These beds extend from 230 feet to 600 feet in length, dipping to the north-east at an angle of 10 degrees. They occur in lenticular forms, varying in thickness from a few inches to over ten feet. The content of copper in the ore averages 5 per cent.

The dressing mill consists of three grizzlies, one Blake crusher of 60 long tons capacity in ten hours, two trommels and four round picking tables 10 feet in diameter, attended by eight women and washing baskets.

Smelting is carried on by the roasting and smelting of the roasts and Mabuki or the blowing of the produced matte for black copper.

The smelting plant consists of 148 open stalls of some 74 long tons daily capacity for all, one Pilz furnace 3.3 feet in diameter, and one rectangular jacket furnace 3 feet wide and 5 feet long (the daily capacity of the two furnaces together is 90 long tons) twelve Mabuki hearths (in which four are usually employed for the daily treatment of 3.7 long tons of matte) and one No. 4 Root's and one No. 5 Green's blower.

Besides one 3 feet Pelton water wheel that is directly used for blowing engines, all the motive power is furnished from two power stations: I. station contains one 220 H.P. water wheel and one three phase alternating current 150 k.w. dynamo of 2,300 volts;

II. station contains one 650 H.P. water wheel and one magnetic field rotary three phase alternating current dynamo of 400 k.w. and 2,200 volts with one 12 k.w. exciter furnished with one Pelton wheel.

Eleven motors of various powers are now in actual use, i.e. blowers of 75 H.P., for ventilation 7.5 H.P., for winding 75 H.P. (for two places), for rubbish transportation 54 H.P., for pumping 15 H P. and for dressing 15 H.P.

The total number of labourers amounted to 1,021 persons, consisting of miners 406, dressing hands 100, smelters 63, porters 133, workmen 76 and assistant labourers 242.

Products for the last five years:—

| | Ore in long tons. | Black copper in long tons. |
|---|---|---|
| 1904 | 29,379 | 898 |
| 1905 | 29,568 | 973 |
| 1906 | 27,996 | 976 |
| 1907 | 28,672 | 847 |
| 1908 | 26,969 | 870 |

## THE KAMAISHI IRON MINE.

It was discovered in 1823. Afterward the government operated it on a larger scale but the operations resulted in failure, after which C. Tanaka succeeded. The area for working extends to 15 miles by 10 miles, at the centre of which and 15 miles west of the harbour of Kamaishi the Kataba mountain 4,000 feet high stands; and the deposits lie at 1600—3300 feet high on the north and south slope of the mountain. The main works and office are placed at the harbour of Kamaishi. A branch of the works stands 15 miles north of Kamaishi where only charcoal pig is produced. The traffic about there is performed by several aerial wire ropes, tramways of 37 miles 29 chains length and railways of 5 miles 66 chain in length. The capital invested since Tanaka's possession is about £520,000. Many pockets of magnetite occur between the granite or diorite and Paleozoic rocks (chiefly limestone), the gangue being garnet, epidote, pyroxene, etc. Copper ore can be picked in some parts and the northern part contains some gold. The deposits are said to be contact metasomatic ones. The main ore lenses range somewhat in one north-west course of about 16,000 feet in length, of which those operated at present may be seen from the following table:—

| Name of deposit or division of mine. | Extension of the deposit. | Analyses of ores Fe. % | $Al_2O_3$ % | $SiO_2$ % | CaO % | S. % | P. % | Cu. % | Smelted ore in 1908 in long-tons. |
|---|---|---|---|---|---|---|---|---|---|
| Shimodate | 160′×330′ | 65.36 | 1.41 | 3.82 | 1.43 | 0.03 | 0.04 | 0 04 | 5,645 |
| Sahinai | 510′×420′ | 48.82 | 3.56 | 14.55 | 11.82 | 0.02 | 0.04 | trace | } 36,935 |
| Motoyama | 48′×135′ and 110′× 25′ | 62.83 | — | 5.20 | — | — | 0.06 | 0.11 | |
| Shinyama | 360′×150′ | 64.28 | 1.20 | 4.37 | 2.02 | 1.12 | 0.03 | 0.28 | } 23,406 |
| Jōyama | 800′×180′ | 56.69 | 1.50 | 13.71 | 1.83 | 0.38 | 0.03 | 0.40 | |
| Taisenzan | ? | 64.52 | 1.08 | 3.98 | 2.19 | 0.07 | 0.04 | 0.05 | 747 |
| Futamata | ? | 62.68 | 1.50 | 5.28 | 1.86 | 1.22 | 0.04 | 0.24 | 3,464 |
| Odake | ? | 61.77 | 2.27 | 5.02 | 2.30 | 0.02 | 0.04 | 0.01 | 2,291 |

The ore is obtained chiefly from open-work, but little from the underground workings. In the former, the overburden is taken away in a slope of some 45° and the ore-body in steps of various heights according to conditions. The method of underground working is applied at Shinyama and Futamata, in which one adit is driven in every 60—70 feet height and ore wider than 30 feet is worked by two parallel levels, leaving pillars of from 12 to 15 feet square between them. One miner excavates 1.5 long tons of lump-ore in 10 hours in the open-workings and 0.93 long tons in the underground. The ore smaller than $\frac{5}{8}''$ is thrown away which amounts to about 10% of the lump; and copper-bearing ore is sorted by manual labour into 2 5% Cu after being sledged to $1\frac{1}{4}''$.

As it is magnetite, the ore is first roasted in 34 Silesian or Cleveland furnaces and sledged to 4″—5″ before it goes to the blast-furnaces, specifications of which are given as follows:—

| Name of furnace, works. | No. 3 in Kamaishi. | No. 1 and 2 Kamaishi. | No. 5 and 8 Kamaishi. | No. 4 and 6 Kamaishi. | No. 7 branch work. |
|---|---|---|---|---|---|
| Approximate quantity of pig produced in 24 hours. | 60 long tons. | 25 long tons @ | 15 long tons @ | 10 long tons @ | 12 long tons. |
| Height. | 75 feet. | 60 feet. | 49 feet. | 40 feet. | 40 feet. |
| Diameter at belly. | 16.5 feet. | 13.2 feet. | 11.0 feet. | 9.2 feet. | 9.5 feet. |
| Hot stoves number and type. | 3 Cowper. | 3 Whitwell. | 3 Whitwell. | 3 Whitwell. | 3 Whitwell. |
| Heating surface of the stoves. | 25,000 ft. | No. 1 Fur. 6200 sq. ft. No. 2 Fur. 4800 sq. ft. | 1800 sq. feet. | 1600 sq. feet | 1600 sq. feet. |
| Type of blowing engine. | Seraing vertical engine of Cockerill Belgium. | Seraing horizontal engine of Cockerill for No. 1. Fur. Vertical condensing engine of Gallow and Son in Manchester for No. 2. | Horizontal non-condensing Wolf compound engine, made in Japan. | Horizontal condensing compound engine. | Horizontal condensing compound engine, made in Japan. |
| Engine's horse-power. | 650 H.P. | 260 H.P. | 110 H.P. | 80 H.P. | 90 H.P. |
| Hoisting engine. | 95 H.P. double Cyl. steam engine. | 95 H.P. Engine; ditto for both furnaces. | 20 H.P. double cylinder steam winch for both furnaces. | 17 H.P. winch for both furnaces. | Manual winch. |
| Kind of fuel. | Coke. | Coke. | Coke. | Coke and charcoal. | Charcoal. |
| Styles of arrangements. | — | Somewhat like the American style. | Somewhat like the English style. | English style. | — |

The charging apparatus for all are Cap and Cone. Pig is tapped 6 times a day and classified into No. 1, No. 2, No. 3 and white pig. Special pigs such as Sabinai pig, spiegel-eisen, ferrosilicon, etc are sometimes made in smaller furnaces. Steel making is performed in two basic open-hearths of 6 and 7 long tons charge, gaseous fuel being supplied from five Dowson's gas-generators; there are also six reheating reverberatories, 550 mm. dia. three high rolls, 440 mm. three high rolling mills, 10″ four high rolls, 8″ rolls and other necessaries ; the first and second rolls being driven by 1800 H.P. triple-expansion marine engine and the third by 250 H.P. compound engine and the fourth by 150 H.P. steam engine. It is intended to build one more 8 long ton open-hearth and 12″ rolls of 440 H.P. Here, rails (smaller than 30 lbs.), square bar (smaller than 4½″ square), round bar (smaller than 3″ dia.), angle (not wider than 3″), etc. are producible. Besides these, so-called "refined pig" is often manufactured from No. 1. charcoal-pig in 12′ × 5′ reverberatory, adding manganiferous stuff.

1500 long tons of gas or water pipe of 3″—36″ dia. and 150 long tons of kettles, etc., can be produced from the casting plant, in which pipe larger than 8″ dia. is cast in moulds arranged in rows and smaller pipe in moulds placed concentrically around a revolving crane. There are six cupolas, three blowers, fourteen cranes, four gas-generators and other accessories. Also there is a fitting shop having thirty-one lathes, nine foundry beds and other equipments. The coke-plant consists of two disintegrators, four Harz jiggers, two Elliot's coal-washers, one hundred and seventy-three Coppee and thirty beehive coke-ovens with three portable coke pushing engines ; and produces 7000 long tons of coke a month from the coals out of the mines of Yūbari, Rumoi, Miike, Kai-ping, etc. Fire bricks are made from Kuji or Iwaki clay, there being four brick-making furnaces and other necessaries and producing 100 long tons a month. As an auxiliary work, copper ore is smelted, with quartz from Kinkwaseki in Formosa, in 3.3′ furnaces and six Mabuki hearths into blister-copper containing 95 % Cu, 0.035 % Au and 1.104 % Ag which is sent to the Mitsubishi Osaka refinery. Besides those in steel making, future improvements are that of a No. 3. blast furnace, which will be made 1.3 times larger, that of a pier, the replacement of the tramway by a railway and the new setting of several lines of wire-ropes.

As to the sources of power, 5,211 H.P. steam engines and 65 H.P. Pelton wheels are used, exclusive of small engines for pumps, etc. There are also five steamers of 16,808 tonnage.

We shall write down here as usual several tables before coming to the end :—

Analyses of products :—

| | Combined C % | P % | Free C % | Si % | Cu % | Mn % |
|---|---|---|---|---|---|---|
| Coke pig | 0.64 | 0.13 | 2.85 | 0.03 | 0.25 | 0.4 |
| Charcoal pig | 0.74 | 0.13 | 2.46 | 0.02 | 0.25 | 0.35 |
| Spiegeleisen | 5.0 —4 1 | 0.24—0.18 | — | 0.01—0.02 | 0.18—0.22 | 20.4—10.4 |
| Ferromanganese | 7.4 —6.8 | 0.38—0.31 | — | tr. | 0.10—0.12 | 70.6—50.4 |
| Steel | 0.55—0.10 | 0.04 | — | 0.04—.03 | 0.23—0.25 | 1.1—0.3 |

Productions in long tons :—

| Year. | Pig. | Steel. | Pipes. | Spiegeleisen etc. | Copper | Gold troy oz. |
|---|---|---|---|---|---|---|
| 1904 | 26,438 | 4,611 | — | 569 | — | — |
| 1905 | 37,255 | 4,163 | — | 4,346 | — | — |
| 1906 | 29,120 | 3,658 | 4,183 | 4,176 | — | — |
| 1907 | 30,361 | 3,944 | 6,912 | 4,007 | 25.6 | — |
| 1908 | 34,264 | 1,649 | 12,788 | 785 | 47.5 | 2,023 |

There are 873 persons in mining, 2,725 in metallurgy, and 1,957 for other working, thus making a total of 4,545 persons.

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## THE SENNIN IRON MINE.

The mine is situated in the mountainous district of Waga county in Iwate prefecture, the distance to Kurosawajiri station on the Tokyō-Aomori railway is about 13 miles east and its height is 533 feet above the sea level.

The country rocks in the mine are limestone, so-called gneiss of Palaeozoic formation and granite; the limestone exists at the upper level and the iron deposits are mainly contained in the limestone and granite in irregular massive forms, so that it is impossible to state clearly their strikes and dimensions. The deposits are often associated with garnet, chlorite and occasionally with copper ore, which seems payable, so that it is intended to design a blast furnace to smelt the copper ore.

In many cases each deposit has a large outcrop hence it does not require prospecting. For mining, open working is mainly adopted, but at the places, where the rocks that cover the deposits are so thick that it is no longer economical to do open working, the method of underground working is adopted. The ore is excavated by underhand stoping for open working and by pillar working for underground working. All the working places at the present are above the drainage level, hence the pumping of mine water is not yet required.

Gangues are picked out at each mining place, consequently the dressing is very simple; at first, the ore is crushed into lumps of about 6 inches in diameter by spalling and is classified into two kinds according to its richness, the richer one being sent to the blast furnaces, but the poor ore is subjected to the roasting process in the furnaces and after being crushed is then sized by the $\frac{2}{3}$ inches diameter sieve; the dressed ore contains 50 per cent iron.

Near the river Waga, the smelting works stand side by side with ore bins, casting and welding rooms. There are two blast furnaces, the one produces 12 long tons of pig iron and other 6 long tons of pig iron per day with charcoal fuel.

Charging materials for one charge:—

| Furnace. | Charcoal | Ore. | Limestone. | Manganess. | No. of charegs per day. |
|---|---|---|---|---|---|
| 1st | 3.33 cwt. | 3.33 cwt. | 1.11 cwt. | 0.111 cwt. | 150 |
| 2nd | 1.85 „ | 1.85 „ | 0.53 „ | 0.037 „ | 180 |

The waste gases from these furnaces are introduced to hot stoves for blast heating and it is heated 400°—500° C for first furnaces and 400°—300° C for second furnaces, the blast pressure being $2\frac{1}{2}$—3 and 2—$2\frac{1}{2}$ inches mercury column respectively. The molten iron is run into the sand moulds every four hours and the slag is removed once each hour.

The dimensions of the furnaces:—

| Furnace. | Height. | Inside dia. at tuyere level. | Inside dia. at charging floor. | Produced pig iron per 24 hrs. |
|---|---|---|---|---|
| 1st | 39.1 ft. | 4.6 ft. | 8.0 ft. | 12 long tons. |
| 2nd | 28.4 „ | 3.1 „ | 5.0 „ | 6 „ |

There are over 24 miles of light railway in the mine, hence all substances are transported with very great facility. The transportation of daily necessary substances and products is carried on by the same way. They can be also sent by waggons to Yokote, a station on the Ōu line.

The total motive power is 134 H.P. which is produced from six boilers.

Annual productions for the last five years:—

| | Ore long tons. | Pig iron long tons. |
|---|---|---|
| 1904 | 8,394 | 2,978 |
| 1905 | 9,927 | 3,700 |
| 1906 | 11,527 | 4,260 |
| 1907 | 13,082 | 3,070 |
| 1708 | 9,549 | 2,885 |

Number of labourers:—For mining 79, for smelting 30, for dressing 58, for transportation 95, for workshop 68 and for miscellaneous work 628; total 958.

## THE KOBUI SULPHUR MINE.

The Kobui sulphur mine is situated in Kameda county at Oshima in Hokkaidō. It is about 5.6 miles from the port of Kobui and the tramway is laid on the whole distance. A small steamer navigates between the port and Hakodate every day. Hence, all the necessary materials and goods for the mine are supplied from Hakodate.

The sulphur deposit is of a superficial occurrence, often covered by red earth or volcanic ashes, about 5 feet thick, and the rock underlying the deposit is almost invariably of a white tuff. The thickness of the deposit varies from 2 feet to 30 feet, the south-east part of the deposit being thicker than that of the north-west part.

The mining method is of a modified long wall system, which is usually adopted in the case of steep coal seams. The ore is excavated with picks, but occasionally chisels and hammers are used at the hard rock portions.

There are three main levels in the mine, that is Nibankō (height 7 feet, width 7 feet), Sinkō (height 7 feet, width 9 feet), Ōgirikō (height 8 feet, width 8 feet), and the tramways are laid on each level, and the ore is brought from the mine in tubs by means of manual labour.

The raw ores are separated in the underground working into ores and rubbish, but the raw ores which can not be completely separated in the underground workings are brought up to the surface dressing mill and are subjected to spalling and cobbing there, and the richness of the sulphur in the dressed ore is 60 per cent. on the average.

The ores are subjected to retorting and the pure solid sulphur is obtained from the vaporized sulphur by cooling. For the refining 200 retorts are provided.

The number of labourers at the end of 1908 was 401 totally.

Annual production for the last five years:—

| Year | Ore in long tons | Sulpeur in long tons. |
|---|---|---|
| 1904 | 16,815 | 5,934 |
| 1905 | 16,590 | 5,585 |
| 1906 | 16,827 | 5,436 |
| 1907 | 19,126 | 5,569 |
| 1908 | 21,567 | 5,575 |

## THE IWAONUPURI SULPHUR MINE.

The name is derived from Mt. Iwaonupuri where the mine is located. The mountain stands on the boundary between Shiribeshi and Iburi, its height being 3,700 feet above the sea level and even now it is still more or less in volcanic action.

The district consists of andesite, propylite and volcanic ash. The deposits are classified into two kinds according to their genesis, one is of sublimation by volcanic action and the other is the deposition of sulphur from hot springs. The former exists mainly above the half way distance up Mt. Iwaonupuri and the latter exists at the foot of it. It is the latter which is mainly worked at present and contains 76 per cent. of sulphur on the average.

The sublimated deposit is exposed to view so that there is no difficulty in locating it but it, from the sulphur springs is in a valley and is hidden from view covered by clayey rocks with vegetation. Hence we can find the deposit by shaft sinking or boring. The deposit worked at present is at a depth of 60 feet below the surface, the precipitated deposit is worked by open working. The thickness of the deposit varies from 10 to 40 feet containing from 2 to 4 feet of clay bands within it.

The ore needs no dressing except the picking out of the clayey matter from the ore. There are two ways of refining, that is (1) the fusing method and (2) the distillation method :

1. Sulphur in the ore is fused in 16 circular fusing iron kettles (diameter 2 feet 5 inches and length 12 feet) by steam from three Lancashire boilers and the fused sulphur is congealed. By this way over 100 long tons of ore can be treated in a day.

2. The ore heated in iron retorts and the sulphur is distilled. These six retorts are arranged on a fire place and treat over three long tons a day; at present there are two fire places, and about 7 long tons of ore are treated in a day.

Products are transported to Iwanai, a small seaport at the west coast in Hokkaidō, by a wire rope tramway for nearly one half of the distance and the other one half by waggons, the total distance being about ten miles.

The number of labourers:—

| | |
|---|---|
| Miners | 74 |
| Refiners | 70 |
| Transporters | 16 |
| Workmen | 15 |
| Miscellaneous | 121 |

Annual production for the last five years:—

| Year. | Raw ore | Refined Sulphur. |
|---|---|---|
| 1904 | 11,227 long tons | 2,251 long tons |
| 1905 | 10,532 „ | 2,185 „ |

| | | |
|---|---|---|
| 1906 | 10,463 long tons | 2,040 long tons |
| 1907 | 7,466 „ | 1,578 „ |
| 1908 | 17,074 „ | 3,002 „ |

As the above table shows, the sudden increase of the product in 1908, was caused by the enlargement of the smelting apparatus and the improvement of the means of transportation. There is still a surplus capacity for transportation so that it is intended to convey the product to market merely as ore.

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## THE NUMAJIRI SULPHUR MINE.

This mine is situated on the west slope of a volcano called Numajiri, an explosion of which some nine years ago caused the death of several persons who were working there at the time, the altitude of the mine is 4,000 feet above sea level, while the metallurgical plant stands about 1,100 feet below it and within 9 miles of Inawashiro, a station on the Ganyetsu line, a branch line of the Tokyō-Aomori railway, from there provisions, etc. are obtained. The deposit is said to have been formed by the impregnation of sulphur through andesite and tuff. This massive deposit measures about 500 feet square and is 60 feet deep in sight, yet the full extent to the north, east and downward are not yet determined.

As it lies at a ravine running from the east to the west, adits are cut to the north and southward at a distance of from 36 feet to 48 feet, and the deposit is worked somewhat like pillar working. Open work is started in south direction from the adit mouth with 6 feet wide and 6 feet high steps and will reach as far as 150 feet from the adit mouth. The average depth of the overburden is estimated as 60 feet. In the middle of 1909, an attempt is being made to reach the north-eastern part of the deposit by boring from the surface by means of manual labor. At the same time the miners are driving an exploration level and an adit level from the east extremity and from a level 20 feet lower than the present bottom. Open workings at the north side will be put in active operation immediately after the course of the rivulet which runs above this part undergoes a change. The average tenor of the mined ore is 45% sulphur. The ore is conveyed to a dressing house, which stands 1.8 miles distant, by Tamamura's patent aerial tramway of 150 long tons capacity. The mined ores in 1907 and 1908 were 8,040 and 20,686.5 long tons respectively.

In the dressing mill the ore is first sledged into 3″ diameter, and fed into one of two ore-crushers of the coal mine type, driven by a 25 horse power steam engine; and is sifted by grizzlies and hand sieves into 3″—⅝″, ⅝″—¼″ and smaller than ¼″. The last mentioned cannot be treated by the present methods in metallurgy on account of its insufficient distillation power caused by its fineness, so that it is stored at present, awaiting the further improvement in the metallurgy. An intention has been expressed to subject it to the carbon bisulphide method or to the electro-chemical process.

Up to a recent date the steam melting process had been employed, but as to the sulphur extraction, it is very inferior to pot distillation. One hundred and fifty kettles, 3 feet diameter 2.5 feet deep made of 1¼ inches thick cast iron are in operation with various modifications. Each ten pots discharge distilled sulphur into one condensing adopter of 4 feet dia. and 14.6 feet long and each five pots have one fire grate in which 50—60 cubic feet of seasoned beach-wood are consumed per day, each pot having two charges of 1.7 long tons ore per day. Flower of sulphur to the amount of 2% of the charge is caught in a sublimation chamber, which consists of five compartments, and returned to the distillation pots. The sulphur extraction amounts to 75—78% of the original charge of ore.

This residue consists almost entirely of volcanic ash and is used as mortar for the binding of furnace-bricks. The extracted sulphur has 99.8% sulphur and neither sellenium nor tellenium, the remaining being volcanic ash. At present the mine is producing on an average 16 long tons of sulphur per day, but in the immediate future 50 pots will be added, when the capacity per day will be 24.5 long tons. The output in 1907 and 1908 was 1,544.6 and 5,284 long tons respectively. Each mould or bar of sulphur is packed and shipped to Yokohama from whence they are exported to Australia, America or Europe. As to methods of conveyance, Tamamura's single rope system aerial tramway is almost finished. It is to run from the metallurgical works to the foot of the mountain which is situated 7,000 feet distant and 450 feet below. An 8 H.P. water wheel will move it and its carrying capacity is estimated at 30 long tons per day for either the up or the down trips. In the near future, a 10 miles long tramway will be erected from the end of the wire rope tramway to Kawageta, a station on the Ganyetsu line.

The number of workmen at the end of 1908 were 65 for mining, 36 for dressing, 40 for metallurgy and 56 for miscellaneous work; thus totally 218.

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## THE SORACHI COLLIERY.

The colliery lies near by the Otaushunai, a station on the Hokkaidō railway. The coal seams occur in the Tertiary and there are fifteen seams actually working, the thickness of which varies from 2.8—9 feet, their general strike nearly coincides with the meridian and the dips are 50°—80° W.

The coals of the colliery are known as the Sorachi coal and their average analysis is as follows:—

| Moisture % | Volatile matter % | Fixed carbon % | Ash % | Sulphur. % | Specific gravity. |
|---|---|---|---|---|---|
| 1.622 | 30.051 | 60.558 | 7.501 | 0.264 | 1.23 |

There is one main winding shaft 600 feet deep, one main inclined shaft 670 feet deep and one upcast shaft, the coals on the drainage level being worked by driving level mine ways made on each 200 feet level. The coal seams are worked principally by the overhand stoping and frequently by the long wall or pillar and room system. The ventilators in use are six Champion fans of from 4 to 8 feet in diameter, one Guibal fan of 20 feet diameter and on Waddle fan of 35 feet diameter. The mine lamps for the miners and officers are Wolf magnetic locking safety lamps and Clanny safety lamps. The kinds of underground pumps in use are the Deane's pump, the Worthington pump and the turbine pump. The coals are screened by two bar screens, placed one above the other with opposite inclinations, into large blocks, small block and fine coal and the large block is subjected to hand-picking while the small block is jigged and the fine is sent directly to the market, the comparatively inferior fine coal being washed. For transportation above the drainage level a self-acting incline is applied and below the same a steam hauling engine and an electric winding engine are used, while on the drainage level and in the open air four electric locomotives and two Tamamura's patent aerial wire-rope ways are utlized. Besides the above there are many small hauling engines in the underground passages actuated either by electric power or by compressed air.

There are eleven Lancashire, six water tube and six portable vertical boilers. The actual horse power in use is 6,736, in which electrical power (740 H.P.) and pneumatic power 250 (H.P.) are included, the steam power directly applied being :—

| | H.P. |
|---|---|
| Hauling | 360 |
| Ventilator | 260 |
| Pumping | 320 |
| Workshop | 15 |

The number of labourers employed at the end of December 1908 was 1,957. The actual production of coals for five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 166,458 |
| 1905 | 211,559 |
| 1906 | 228,010 |
| 1907 | 201,293 |
| 1908 | 247,379 |

Within a short time in the future, the second electrical power plant, equipped with forty-two turbogenerators of 500 kilowatts and 3,300 volts each and four water tube boilers of 200 pound pressure per square inch will be set up.

## THE PORONAI COLLIERY.

The colliery lies near by the Poronai station on the Hokkaidō railway. The coal seams occur in the Tertiary, and there are five workable seams 3.0—5.5 feet in thickness. The strata strike generally NW and the dips vary from 18°—70° to SW or NE thus going rise to an anticlinal fold.

The coal of this colliery is known as the Poronai coal and its average analyses is as follows:—

| Moisture. | Volatile matter. | Fixed matter. | Ash. | Sulphur. | Specific gravity. |
|---|---|---|---|---|---|
| % | % | % | % | % | |
| 2.58 | 36.61 | 55.98 | 4.24 | 0.95 | 1.27 |

The cross-cuts for the main transportation are cut horizontally from the drainage level against the strike of the strata to attack several coal seams with single cuts, and besides them there are one main shaft of 570 feet depth and one main slope 300 feet depth for the transportation below the drainage level. The striking of the second shaft of square section and 600 feet depth was started in 1909. The seams are worked either by the long wall or the pillar and room system having panels 500—1,000 feet long along the strike and 300 feet along the dip. The coal winning is carried on by kerving with hand picks and then by blasting. The ventilators in use are four Champion fans of eight feet diameter, the same fan of four feet diameter and a Guibal fan of eighteen feet diameter, the Champion fans being moved by electricity. Besides the above there are used temporarily many fans of a smaller type, moved by compressed air. As underground pumps Knowle's duplex pumps and Snow pumps are in use, the motive power being steam or compressed air. The miners and officers use are the Wolf magnetic locking safety lamps or the Clanny safety lamps. The coals are screened by two bar screens, placed one above the other with opposite inclinations, into large block, small block and fine coal and the large block is subjected to hand picking, while the small block is jigged, and the fine is sent directly to the market, the comparatively inferior fine coal being washed. For transportation below the drainage level a steam windlass engine, pneumatic hauling engine and many small temporary hauling engines moved by steam or compressed air are used, while on the drainage level and open light an endless rope of the under rope type actuated by electrical power is utilized.

The actual horse power in use is 1,436 in which electrical power to the amount of 500 H.P. and pneumatic power to the amount of 250 H.P. reduced from steam power is included, the steam power directly applied being :—

| | H.P. |
|---|---|
| Winding and hauling | 380 |
| Ventilator | 100 |
| Pumping | 206 |

The number of labourers employed at the end of December 1908 was 1,238. The annual production of coals for five years ending in 1908 was :—

| | long tons. |
|---|---|
| 1904 | 193,382 |
| 1905 | 203,504 |
| 1906 | 205,074 |
| 1907 | 167,903 |
| 1908 | 187,269 |

## THE IKUSHUNPETS COLLIERY.

The colliery lies near by the Ikushunpets station, on the branch line of the Hokkaidō railway. The coal seams occur in the Tertiary and there are four workable seams. Their strike nearly coincides with the meridian and the varies 45°—80° to W. The coals of this colliery are known as the Ikushunpets coals and their average analysis is as follows :—

| Moisture. % | Volatile matter. % | Fixed Carbon. % | Ash. % | Sulphur % | Specific gravity. |
|---|---|---|---|---|---|
| 1.77 | 47.88 | 45.55 | 7.64 | 0.16 | 1.25 |

At present, the seams above the drainage level are only worked by levels driven from the surface, but within a short time in the future slopes will be driven to work the seams below the drainage level.

The seams are worked by over-hand stoping. For the ventilation of one part of the mine a Champion fan is used. The miners and officers use the Clanny safety lamps. The coal tubs brought out of the mine are elevated by a creeper to the level of 20 feet above the drainage level.

The coals are sized by the bar-screen to block coal and fine coal and the block is cleaned by hand picking while the fine is subjected to washing. There is one locomotive boiler and one steam engine moving the creeper of 20 H.P.

The number of labourers present at the end of December 1908 was 718. The actual production of coals for five years ending in 1908 was :—

| | long tons. |
|---|---|
| 1904 | 80,160 |
| 1905 | 83,042 |
| 1906 | 84,380 |
| 1907 | 67,946 |
| 1908 | 76,847 |

## THE YŪBARI COLLIERY.

The colliery lies near by Yūbari station, on the Yūbari line of the Hokkaido railway, and there are two main pits, namely the First and the Second.

The coal seams occur in the Tertiary and there are in the First mine three seams actually worked, namely, the Main-seam, 24 feet thick with two partings of 0.5 and 3.0 feet thick, the Upper-seam 4 feet thick, lying 300 feet above the Main-seam and the Lower seam 4 feet thick lying 180 feet below the former, while in the Second mine Eight-foot-seam having a thickness varying form 3—25 feet occur. Their strike nearly coincides with the meridian and dip varies from 12° to 20° to W in the First mine and 20°—70° to W in the Second mine.

The coals of this region are known as the Yūbari coals and their qualities can be judged from the following analyses:—

| | Moisture. % | Volatile matter % | Fixed carbon % | Ash. % | Sulphur. % | Specific gravity. |
|---|---|---|---|---|---|---|
| 1st Mine | 1.218 | 42.235 | 51.502 | 4.573 | 0.472 | 1.230 |
| 2nd Mine | 1.390 | 42.612 | 53.017 | 2.650 | 0.341 | 1.243 |

There are in the First mine nine level having independent openings above the drainage level and five main slopes for transportation, and in the Second mine several levels above the drainags level, and two main slopes for transportation.

The coal seams are worked by the pillar and room system having the panels, the length of the panels along strike being 1,000—1,500 feet in the First mine and 1,000 feet in the Second mine and the dip length of the same 300—500 feet in both mines. In the Frist mine, the excavation of mine roads in the barren strata or of cutting faults is facilitated by using No. 2 Water-Leyner rock drills made by the Water-Leyner Company and No. 2 Little Jap rock drill made by the Ingersoll Rand Company. The coal winning is carried on by kerving using either hand picks or by mechanical coal-cutters. As the colliery is one of the most fiery mines in Japan, many ventilators are in use. The ventilators used in the First mine are two Guibal fans of 20 feet diameter, six Champion fans of 8 feet diameter and two Champion fans of 6 feet and 12 feet diameter respectively. Besides the above there are several ventilators in reserve. As the miners and officers lamp Wolf magnetic locking safety lamps and a few Clanny safety lamps are chiefly used. There are seven underground pumps worked by compressed air or electricity, of which four are actually used. The transportation above the drainage level is carried on the self-acting incline on which the tubs run down, while the underground conveyance below the drainage level is carried on in the First mine by one steam hauling engine, one electric hauling engine and one tail-rope hauling and in the Second mine by three steam hauling engines. On the drainage level and in the open light, the transportation is carried on in the First mine by two endless-ropes of the under-rope type, one endless-rope of the over-rope type and four compressed air locomotives, while in the Second mine the temporary railway, 3 miles and 26 chains long on which tubs are drawn by horses, is utilized. The coals are sized by bar-screens to block and fine coal and the block is subjected to hand picking, but comparatively inferior coals are crushed by a crusher and sized in a trommel and then sorted in a jig and two fine coal washers.

There are fifteen Lancashire, ten water tube and six portable vertical boilers. The actual horse power in use is 6,736, in which an electrical power of 1,340 H.P. generated by two Parson's steam turbo-generators, and 1,200 H.P. generated by three generators of electricity, are embraced.

The electrical power reduced from steam power is 2,630 H.P. while the steam power charged to the compressed air is 1,962 H.P., the steam power directly used being:

| | H.P. |
|---|---|
| Ventilators | 300 |
| Hauling | 710 |
| Workshop | 30 |
| Pumping | 1,104 |

The number of labourers employed at the end of December 1908 was 5,921. The annual production of coals for five years ending in 1908 was:

| | long tons. |
|---|---|
| 1904 | 465,399 |
| 1905 | 465,402 |
| 1906 | 607,402 |
| 1907 | 561,009 |
| 1908 | 604,853 |

In the First mine, there is a main shaft for transportation now being sunk or the First shaft, of 18 feet diameter and 550 feet of estimated depth, the sinking having been started in 1907, and the Second shaft or the accessory upcast shaft of the same depth as above will also be sunk hereafter, the designed daily production of coals by these shafts is 1,000 long tons. Four miles north of the First mine there is the Manji mine, the main transportation slope of which has been driven since November 1905. From the mine to the First mine a Tamamura's patent aerial wire-rope way was set in 1909. If these works be completed, 500 long tons of coals will be sent daily from the mine.

In the Second mine there is also sinking a main transportation shaft or the First shaft of rectangular 18′ × 13′ section and 600 feet of estimated depth, the sinking being started about the end of 1908. The temporary railway of the Second mine before mentioned will be replaced by a Tamamura's patent aerial wire-rope way in 1909.

Within a short time in the future, the second electrical power plant, equipped with three generators of 1,000 kilowatts and 3,300 volts each, will be set up and also the mechanical dressing before mentioned will be enlarged hereafter in the First mine.

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## THE SHIN-YŪBARI COLLIERY.

The colliery lies on the district distant 3 miles 50 chains from Shikanotani, a station on the Yūbari line, the Hokkaido railway and embraces two mines namely the First mine and the Second mine.

The coal seams occur in the Teritary, and there are five seams of four feet, six feet, seven feet, eight feet and ten feet in thickness with their strike passing from S. 6° E to S 89° E and the dip is 5°—70° NE. Their average analyses are as follows:—

| Seams. | Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Specific gravity. | Calories. |
|---|---|---|---|---|---|---|---|
| Six-foot-seam | 1.40 | 45.08 | 49.41 | 3.96 | 0.21 | 1.20 | 7,810 |
| Eight-foo-seam | 1.55 | 45.17 | 50.09 | 3.19 | 0.15 | 1.26 | 7,920 |
| Ten-foot seam | 1.22 | 44.21 | 47.87 | 6 69 | 0.18 | 1.28 | 7,480 |

There are eight and two levels in the First and the Second mine respectively. These ways have their individual mine openings on the different levels.

The coal seams are worked either by the pillar and rooms system, the long wall system or by overhand stoping. At present, only small ventilators moved by manual labour are used but within a short time in the future a mechanical ventilator will be set up. No pump is used and the mine water to the amount of 15 cubic feet per minute is drained from the lowest level.

As motive power, electrical power will be used and at present the generator of 375 kilowatts is being set up. The number of labourers employed at the end of December 1908 was 1,583. The colliery started its coal winning in 1906, the annual production of coals for the year and the following two years being 33,276 long tons, 104,244 long tons and 165,391 long tons respectively.

## THE ONODA COLLIERY.

The colliery is situated two miles west of Yumoto, a station on the coast line of Tokyo-Sendai railway. The coal seams occur in the Tertiary and there are two of them actually being worked, namely, the Upper-seam 6 feet thick and the Main-seam 8 feet thick, the vertical distance between them being 100—120 feet. Their strike is SN and the dip 12° E. The coals of this region are known as Iwaki coals and their average analysis is as follows :—

| Moisture. % | Volatile matter. % | Fixed carbon. % | Ash % | Sulphur % | Calories. |
|---|---|---|---|---|---|
| 8.45 | 44.18 | 41.21 | 6.16 | 0.40 | 6,820 |

For prospecting, many borings were driven by the Sullivan B type diamond boring machine and by improved Chinese borings driven by manual labour.

There are three main slopes having the lengths of 4,000, 3,500 and 2,400 feet and two main winding rectangular shafts, one of the latter named the Onoda shaft being of 9′×15′ section and 203 feet depth having one accessory upcast rectangular shaft of 5′×5′ section and 260 feet depth, is used for the windlass winding up the coals from the deeper workings of the First slope, while the other named the Umegahira shaft of 6.5′ × 13.2′ section and 278 feet depth having one accessory upcast rectangular shaft of 6.7′ × 10.4′ section and 270 feet depth is used for raising the coals from the deeper workings of the Third slope. Besides the above there is one rectangular upcast shaft of 6′ × 6′ section and 330 feet depth belonging to the second slope.

The coal seams are worked by the pillar and room system. The coal winning is carried on both by kerving and pick digging. If the coal is soft, pick digging by manual labour is applied but if the coal is hard the method of under cutting or hole cutting by manual labour is employed by making an under cut of two feet in depth and then blasting the same with gun powder. The quantity of powder in the charge used in each blast is about 4 ounces and 4,000 lbs. coals by the blasting of each undercut. The underground transportation on the main slope is carried on by means of hauling engines. There are fifteen Special pumps and one Worthington pump. The screening house is equipped with one gyrating riddle and one travelling band. The coals are sized by the screen into large block and fine coal, and the block is subjected to hand picking on the travelling band.

There are one Lancashire and nine Cornish boilers, the actual steam power in use being 924 H.P. The number of labourers employed at the end of December 1908 was 1,194. The annual production of coals for five years endingin 1908 was:—

| | long tons. |
|---|---|
| 1904 | 73,440 |
| 1905 | 120,958 |
| 1906 | 197,088 |
| 1907 | 188,277 |
| 1908 | 190,562 |

In order to work 420 long tons of coal daily, on the dip side of the present workings, two shafts are in the course of being sunk, one of which being the main rectangular shaft of 7.8′ × 24.8′ section and 350 feet deep, and the other an upcast rectangular shaft of 7.6′ × 14. 4′ section and 340 feet deep. The upcast will be equipped with a Champion fan of 8 feet diameter, after the sinking is completed.

## THE UCHIGŌ COLLIERY.

This colliery is situated two miles north-west of Tsudzura, a station on the coast line, Tokyo-Sendai railway.

The coal seams occur in the Tertiary and three of them are capable of working; namely the Upper-seam 6 feet thick, the Main-seam 7 feet thick and the Lower-seam 2 feet thick, the difference of vertical height between the former two being 100—120 feet, and between the latter two being 6—12 feet. Their general strike is NS and the dip 12° E

The coals of this region are known as Iwaki coals and their average analysis is as follows:—

| Moisture. % | Volatile matter. % | Fixed carbon % | Ash. % | Sulphur. % | Calories. |
|---|---|---|---|---|---|
| 6.70 | 48.45 | 35.03 | 9.82 | 1.87 | 6,820 |

There is one main transportation slope and one main winding and draining shaft, the slope communicating with the level of the shaft bottom at the distance of 2,000 feet along the slope from the slope mouth. The shaft is rectangular 10.8′ × 15.6′ section 420 feet deep. Besides the above there are one Upper-seam-slope 1,067 feet long, one temporary slope 903 feet long, one draining shaft 300 feet deep, the Hirohata upcast shaft 381 feet deep and the Yoshima-upcast-shaft 285 feet deep, the latter three having a rectangular section. And at present an upcast and draining shaft of 7.8′ × 6′ section 430 feet deep is being sunk.

The coal seams are worked by the pillar and room system. In cutting out the coal the method of undercutting is applied by manual labour the depth of the hole cut being 3 feet, and blasting is made in the seam to loosen the coal instead of using wedges. The furnace for ventilation in the Yoshima-upcast-shaft is not in service at present, and after a short time it will be replaced with a ventilating fan. A few years ago there was an enormous influx of underground water, and since that time the influx of the mine water is estimated to 150 cubic feet per minute. The principal part of the mine water is drained by two buckets of 178 cubic feet capacity each, wound up the draining shaft, and the remaining water is pumped up by one compound duplex pump of the 36″—16″ × 9″ type, thirteen Special pumps, two electric pumps and five other pumps. With regard to underground conveyance, on the main slope way hauling and endless rope transportation are applied and on the inclines self-acting planes are in use. There are two screening houses each equipped with one gyrating riddle and one travelling band. The coals are sized by screening into block and fine coal, and then the block coal is subjected to hand picking on the travelling band.

There are nineteen Lancashire boilers and two Cornish boilers. The motive steam power generated is 642 H.P. and the electrical power generated by steams is 50 kilowatts.

The number of labourers employed at the end of December 1908 was 1,408. The annual production of coals for the five years in ending 1908 was:—

| | long tons. |
|---|---|
| 1904 | 120,427 |
| 1905 | 128,625 |
| 1906 | 55,638 |
| 1907 | 145,605 |
| 1908 | 198,936 |

Within a short time in future diamond borings will be driven on the dip side of the present workings.

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## THE IRIYAMA COLLIERY.

The colliery is situated one and a half miles west of Tsudzura, a station on the coast line, the Tokyō-Sendai Railway.

The coal seams occur in the Tertiary and there are five seams of which two or three are workable. Their average strike nearly coincides with the meridian and the dip is 10° E. The Lower seam or Main seam is 8 feet thick on the average, the Upper-three-foot-seam lying about 100 feet above the main seam is 4 feet thick and the Lower-three-foot-seam lying about 8 feet below the same has a thickness similar to the latter.

The coals of this region are known as the Iwaki coals and their quality can be judged from the following analyses:—

| Names of seams. | Moisture. | Volatile matter | Fixed-carbon | Ash. | Sulphur. | Calories. |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | |
| Main-seam | 4.36 | 49.86 | 38.58 | 7.20 | 2.72 | 7,233 |
| Lower three foot seam | 8.20 | 45.70 | 39.40 | 6.70 | 0.56 | 6,600 |

The quality of the Upper-three-foot-seam is nearly the same as that of the Lower-three-foot-seam.

The colliery embraces three mines actually working, namely the Kawahira Mine, the Third Mine and the Fourth Mine. There are in the Kawahira Mine, one main shaft 260 feet deep used for winding, draining and as an upcast and one slope used for communications and as a down cast, in the Third Mine one main shaft 381 feet deep used for winding and as a downcast, and two upcast shafts one of which is actually in the process of being sunk and in the Fourth Mine main one shaft 400 feet deep used for winding and as a downcast and one upcast shaft 350 feet deep. These shafts are all rectangular except one temporary circular upcast shaft in the Third Mine. The length of the main slopes of Kawahira and the Third Mine are respectively 2,100 and 2,640 feet while the length of the rise of the Fourth Mine is 600 feet. For prospecting, several American rope borings were made and a hole at the depth of 1,800 feet is actually being driven.

The coal seams are worked principally by the pillar and Room system and frequently by the long-wall system. In the Third Mine a Capell fan of 7 feet diameter is used. As stationary lamps in the main mine ways electric lamps are used, and as miners and officers lamps the Cambrian, Clanny and Davy Safety lamps are in use. With regard to underground conveyance, on the main slope way in the Third and the Fourth mine endless ropes are used while in the Kawahira mine transportation is carried on by hauling engines. Besides the above there are many self-acting planes on rises and endless ropes on level ways underground. There are 18 small underground pumps and one compound duplex pump of $\frac{16''-26'' \times 8''}{18''}$ type, 75 cubic feet per minute capacity and 356 feet actual lift.

As power generators 15 Lancashire boilers are used. The number of labourers employed at the end of December 1908 was 1,402.

The annual productions of coals for the five years ending in 1908 were:—

| | long tons. |
|---|---|
| 1904 | 154,733 |
| 1905 | 220,299 |
| 1906 | 229,211 |
| 1907 | 204,537 |
| 1908 | 194,743 |

In the future 400 kilowatts electrical power will be generated by setting up two generators, the voltage being 2,300 volts. By this electrical power underground turbine pumps and underground endless ropes will be put in action.

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## THE YOSHIMA COLLIERY.

The colliery is situated three and a half miles south-west of Tsudzura, a station on the coast line of Tokyō-Sendai Railway, and embraces two mines, namely the First and the Second Mine.

The coal seams occur in the Tertiary and are two of them are workable, namely, the Upper-seam of 9 feet thick and the Lower-seam of 7.5 feet thick, their vertical distance varying from 60—110 feet. Their average strike is N 10° E and the dip 10° SE. There is a large fault having a throw of 250 feet, running from west to east and dividing the concession into two equal parts approximately. The First Mine is working seams on the southern part of the fault and the Second mine on the north.

The coals of this region are known as Iwaki coals. The First mine has two main slopes for transportation 2,880 feet and 2,100 feet long respectively and one accessory upcast slope, while the Second mine has one main slope for transportation 1,860 feet long, and one accessory upcast slope.

The coal seams are worked by the pillar and room system having panels, the size of the pillars being from 20 to 24 yards square. The panel of 30—40 yards thick is left around each hundred pillars in ten rows and ten columns. For pumping, five simplex pumps and one duplex pump are in use. The underground transportation in the First mine is carried on by the endless-rope of an over-rope type and in the Second mine by a hauling engine, but within a short time in the future this hauling engine will be replaced by an endless-rope. There is one screening house in the First mine; the coals being sized by the grizzly and then by a movable bar-screen are sorted on the travelling picking band. In the open light there is an endless rope connecting the Second slope and the screening house 35 chains apart.

There are four Lancashire and two Cornish boilers in use. The steam motive is distributed as follows:—

| | H.P. |
|---|---|
| Transportotion | 408 |
| Dynamo | 20 |
| Workshop | 12 |
| Screening house | 20 |
| Pumping and feeding | 358 |
| Total | 816 |

The electrical power generated is 10 kilowatts. The number of labourers employed at the end of December 1908 was 1,348.

The annual production of coal for four years ending in 1908 was:—

| | long tons. |
|---|---|
| 1905 | 66,516 |
| 1906 | 112,518 |
| 1907 | 138,990 |
| 1908 | 126,827 |

## THE MIYOSHI COLLIERY.

The colliery lies one mile distant from the Orio station on the Kyūshū railway. The coal seams occur in the Tertiary and there are two workable seams, of which one is the Five-foot-seam 4.6 feet thick with two partings of 0.4 and 0.6 feet, and the other the Three-foot-seam, lying 180 feet below the former, 4.3 feet thick with two partings of 1.2 and 0.15 feet, their strike being N 65° W and the dip 18° NE.

The coals of this region are known as the Onga coals. There are two main slopes for transportation and two accessory slopes. The coal seams are worked by the pillar and room system, while the underground pumps in use are one Evan's pump and twelve Special pumps. The underground transportation is facilitated by four hauling engines. The coals are sized by bar screens to block and fine coal. There are eight Lancashire and two Cornish boilers. The number of labourers employed at the end of December 1908 was 731.

The annual production of coals for four years ending in 1908 was :—

| | long tons. |
|---|---|
| 1905 | 48,624 |
| 1906 | 105,222 |
| 1907 | 99,654 |
| 1908 | 120,653 |

## THE ŌTSUJI COLLIERY.

Ths colliery is situated on about one mile south-west of Nakama, a station on the Chikuhō line of the Kyūshū railway and embraces three mines namely the First mine, the Fourth mine and the Branch of the Fourth mine.

The coal seams occur in the Tertiary and there are three of them actually worked namely the Three-foot-seam 3 feet thick, the Four-foot-seam 3.5 feet thick and the Takaye-seam 3 feet thick.

The coals of this region are known as Onga coals and their average analysis is as follows:—

| Moisture % | Volatile matter. % | Fixed carbon % | Ash. % | Sulphur. % | Calories. |
|---|---|---|---|---|---|
| 4.26 | 42.3 | 46.11 | 7.24 | 0.90 | 6,875 |

There are in the First mine one main slope for transportation, one draining shaft and one shaft for communication, in the Fourth mine there are two main slopes for transportation and one upcast shaft, and in the branch of the Fourth mine there are two main slopes for transportation.

The coal seams are worked either by the pillar and room or by the long wall system. At present, there is no ventilator but within a short time in the future a Capell fan will be set up. Pumps in use are two duplex pumps, twenty-five Special pumps, three Evan's pumps and six Cameron pumps. There are six hauling engines for underground transportation and three air line endless ropes. The coals are sized with seventy-six fixed grizzlies to block and fine coal.

There are eighteen Lancashire, eleven Cornish boilers and one Eddison's 15 kilowatts dynamo moved by steam power.

The number of labourers emplyed at the end of December 1908 was 1,447.

The production of coals for five years ending in 1908 was:

| | long tons. |
|---|---|
| 1904 | 269,558 |
| 1905 | 209,759 |

| | |
|---|---|
| 1906 | 194,732 |
| 1907 | 262,304 |
| 1908 | 365,075 |

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## THE SHIN-NYŪ COLLIERY.

The colliery is near by Nōgata, a station on the Chikuhō line of the Kyūshū railway and embraces five mines.

The coal seams occur in the Tertiary and three of them are workable. Their properties can be judged by the following analyses :—

| Names of seams. | Moisture. % | Volatile matter. % | Fixed carbon. % | Ash % | Sulphur. % | Specific gravity. | Calories. |
|---|---|---|---|---|---|---|---|
| Kankan | 3.06 | 35.90 | 47.16 | 13.88 | 0.62 | 1.214 | 6,490 |
| Five-foot-seam | 2.00 | 41.70 | 44.90 | 11.70 | 0.62 | 1.419 | 6,820 |
| Three-foot-seam | 3.41 | 42.76 | 48.46 | 5.37 | 0.22 | 1.311 | — |

In the First mine there are two shafts and two slopes in which one shaft is used as the main shaft for coal winding, the length of the main slope being 4,637 feet. In the Second, Third, Fourth and Fifth mines there are respectively three shaft and two slopes, one shaft and two slopes, one shaft and three slopes and one shaft and two slopes, in which one main slope in each mine is used for coal winding while the remaining openings are used for the remaining use as above mentioned, the length of the main slopes in the mines are respectively 2981, 3797, 5226 and 4368 feet. The ventilators used are four Guibal fans in the First, Third, Fourth and Fifth Mine discharging respectively about 90,000, 71,000, 75,000 and 57,000 cubic feet of foul air per minute and one Champion fan discharing about 51,000 cubic feet. The large pumps used are three Worthington compund dulplex pumps of the $\frac{20''\text{-}32'' \times 42''}{10\frac{1}{2}''}$ type. The transportation on the main slopes is carried on by hauling engines and in some parts both in the under ground and on the overground workings endless ropes are utilized.

There are forty eight boilers and two generators of electricity, the electrical power generated by one generator being 500 kilowatts. The actual motive power in use is 5,519 H.P.

The number of labourers employed at the end of December 1908 was 4,945. The annual production of coals for the five years ending in 1908 were:—

| | long tons. |
|---|---|
| 1904 | 425,051 |
| 1905 | 413,594 |
| 1906 | 375,488 |
| 1907 | 438,573 |
| 1908 | 426,621 |

In the near future a circular upcast shaft 600 feet deep will be sunk in the First Mine in order to get a better ventilation.

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## THE ŌNOURA COLLIERY.

The colliery is situated three miles west of Nōgata, a station on the Chikuhō line, the Kyūshū railway, and embraces three mines namely the Sugamuta, the Kirino and the Man-noura mine.

The coal seams occur in the Tertiary and there are two seams actually being worked, namely, the Three-foot-seam 7.2 feet thick and the Five-foot-seam 5 feet thick, their strikes varying from N 45° E to N 55° W and the dips from 15° SE to 15° NE in average.

The analyses of the coals are as follows:—

| Name of seams. | Moisture. % | Volatile matter % | Fixed Carbon. % | Ash. % | Sulphur. % | Calories. % |
|---|---|---|---|---|---|---|
| Ōnoura-three-foot seam | 2.11 | 43.97 | 47.77 | 6.14 | 0.33 | 7,645 |
| Ōnoura five foots-eam | 1.42 | 46.10 | 41.66 | 10.82 | 3.82 | 7.150 |

There are two main slopes for transportation in each mine and as accessories in the Sugamuta Mine one slope for communication and one shaft for draining; in the Kirino Mine there are two draining shafts and one slope for communication and in the Mannoura mine two draining shafts and two slopes for communication.

The coal seams are worked by the pillar and room system. In each two Champion fans are set discharging from 80,000 to 90,000 cubic feet of foul air per minute each. Underground pumps in use are three Worthington pumps, thirteen Evan's pumps and fifty one Special pumps. The underground transportation on the main slopes is carried on by hauling engines, while surface transportation is done by five endless-rope engines. In the screening houses in the Sugamuta and Kirino mine movable screens and travelling bands are set and the coals are sized into large blocks, middle sized blocks and fine coal, the former two being subjected to hand picking on the travelling bands.

There are forty-six Lancashire and fourteen Cornish boilers and two generators of electricity generating 150 kilowatts of electrical power each. The number of labourers employed at the end of 1908 was 6,195.

The annual production of coals for five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 545,250 |
| 1905 | 585,257 |
| 1906 | 615,949 |
| 1907 | 794,125 |
| 1908 | 771,291 |

Within a short time, the present low-pressure boilers will be replaced by eleven Thomson's high-pressure boilers of 7′3″ diameter and 30 feet in length.

## THE MITSUI-HONDŌ COLLIERY.

The colliery is situated seventeen chains north-west of the Nakaidzumi station, on the Chikuhō line of the Kyūshū railway and embraces three mines namely, the First, Second and Third mines.

The coal seams occur in the Tertiary and there are two seams, being actually worked, namely, the Three-foot-seam and the Five-foot-seam, their strike being S 35° E and the dip 17°—18° NE.

Their average analysis is as follows:—

| Moisture % | Volatile matter. % | Fixed carbon. % | Ash % | Sulphur. % | Calories. |
|---|---|---|---|---|---|
| 3.50 | 39.07 | 45.12 | 3.31 | 0.27 | 7,370 |

There are three main slopes for transportation, two upcast slopes and three upcast shafts, the length of the main slopes of the three mines being respectively 3,420, 3,240 and 2,988 feet. The excavation of mine ways in rocks are facilitated by utilizing Little Wonder rock drills.

The coal seams are worked by the long wall system. The mine timbering and underground pumping are the most tedious work of the colliery. As the pressure from the roof is heavy, close timberings are made through the whole length of the main mine ways, but some of them are broken within the period of two or three months. For pumping, nine Jeanesville duplex pumps requiring together 756 horse power, four Evan's pumps, fifteen electric turbine pumps and fourteen electric three throw pumps, requiring a gross horse power of 1,296 are used. Ventilating fans in use are one Sirocco fan of 4.5 feet diameter and 150,000 cubic feet capacity and one Champion fan of 10 feet diameter and 100,000 cubic feet capacity used alternately in the First mine; one Sirocco and one Champion fan of similar types to the above mentioned, used respectively in the Second and Third mine. Besides the above there are four local fans temporarily used. The underground lamps in use are the Davy lead pin locking safety lamps. The underground transportation is facilitated by five hauling engines while in the open day light three endless ropes are utilized.

There are two similar screening houses in the First and Third mines. The screening house is equipped with a movable bar-screen, circular trommels and travelling bands. The coals are screened by the former two to large block, small block and fine coal, the blocks being subjected to hand picking on the bands separately, after picking they are gathered and sent to the market. The coals from the Second mine are sent by endless-ropes in the open light to the screening house of the Third mine.

There are twenty three Lancashire and four Wilcock and Babcox water tube boilers by which all the engines and machineries are moved and also two generators of electricity of 200 kilawatts and 3,200 volts each. The total electrical power generated by the steam is 457 kilowatts.

The number of labourers employed at the end of December 1908 was 3,084. This colliery was bought by the present owner on the 10th in July 1907, therefore the precise annual production corresponding to the present arrangements can only be judged by that of 1908 which was 195,915 long tons.

In a short time within the future two more generators of electricity of 200 kilowatts and 3,200 volts each, will be set up.

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## THE AKAIKE COLLIERY.

The colliery is situated one mile west of the Kanada station, on the Chikuhō line of the Kyūshū railway, and embraces two mines namely the Main and the Third mines.

The coal seams occur in the Tertiary and there are two seams actually worked, namely, the Three-foot-seam and Five-foot-seam, their strike being N 30° W and the dip 13° NE.

The quality of the coals can be judged from the following analyses:—

| Seams. | Moisture % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Specific gravity. | Calories. |
|---|---|---|---|---|---|---|---|
| Three-foot-seam | 3.355 | 38.356 | 54.555 | 3.180 | 0.374 | 1.288 | 7,563 |
| Five-foot-seom | 2.695 | 40.730 | 53.602 | 2.635 | 0.338 | 1.272 | 7,205 |

For prospecting three diamond borings were made recently. There are one main shaft and one main slope for transportation, two accessory upcast shafts and one slope for communications, the depth of the main shaft being 254 feet and the lengths of the two main slopes in the main mine being 2,400 feet each.

At present the colliery is working by pillars principally but in some parts solid coals are worked by the long wall system. The ventilator in use is one Champion fan of 10 feet in diameter discharging 80,000 cubic feet of foul air per minute. The underground pumps in use are three Jeanesville duplex pumps, six Worthington duplex pumps, one Ideal pump, twenty two Special pumps and three simplex pumps. Miners and officers lamps in use are the Clanny and the Davy safety lamps. The underground transportation is carried on by one windlass engines and three hauling engines. Besides the above there are four hauling engines for miscellaneous use. In the open light there are one creeper two self-acting plane, and one endless-rope to facilitate the work of transportation. The screening house is equipped with one Briart bar-screen, Cox gyrating riddle and travelling band. The coals are sized by the former two to large blocks, small blocks and fine coal, and subjected to hand-picking on the latter.

There are thirteen Lancashire, six Cornish and three multi-tubular boilers, the total nominal horse power being 1,872. The distribution of steam power is as follows:—

| | H.P. |
|---|---|
| Transportation | 1,041 |
| Generator of electricity | 150 |
| Screening house | 31 |
| Ventilator | 60 |
| Workshop | 14 |
| Pumping | — |

The number of labourers employed at the end of December 1908 was 1,444. The annual production of coals for the five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 148,131 |
| 1905 | 191,136 |
| 1906 | 194,715 |
| 1907 | 186,701 |
| 1908 | 172,952 |

## THE KANADA COLLIERY.

The colliery lies on the south of the Kanada station, on the Chikuhō line of the Kyūshū railway.

The coal seams occur in the Tertiary and there are five seams workable, of which four are actually worked, namely, the Nanaheda-seam 8 feet thick, the Tagawa-Eight-foot-seam 9 feet thick lying closely under the above mentioned seam, the Five-foot-seam 5 feet thick lying 12 feet below the Eight-foot-seam, and the Tagawa-Four-foot-seam 4.0—1.5 feet thick lying 46 feet below the same. Their strike is N 18° W and the dip 10°—12° NE.

The quality of the coals can be judged from the following analyses:—

| Names of seams | Moisture % | Volatile matter % | Fixed carbon. carbon. % | Ash. % | Sulphur. % | Specific gravity. | Calories. |
|---|---|---|---|---|---|---|---|
| Eight-foot-seam | 3 37 | 39.73 | 53.22 | 3.45 | 0.33 | 1.28 | 7,370 |
| Four-foot-seam | — | 39.49 | 52.70 | 3.80 | — | — | 7,500 |
| Five-foot-seam | 2.91 | 38.53 | 45.74 | 12.56 | 0.26 | 1.36 | 6,545 |

There are two main slopes for transportation namely the First slope 4,500 feet long on which an electric endless rope is circulating and the Second slope, the conveyance on the latter being carried on by a hauling engine. Besides the above there are one draining slope and two upcasts. The coal seams are worked either by the pillar and room or by the long-wall system. The ventilators in use are one Capell fan of 150,000 cubic feet capacity and one Improved Capell fan of 130,000 cubic feet capacity. The miners lamps are the Cambrian pneumatic locking safety lamps while the officers are allowed to use Davy safety lamps. For pumping one Jeanesville duplex pump of 65 cubic feet capacity and 400 feet lift, two electric turbine pumps are actually used while eight Special pumps are reserved for spare use in emergencies. In the open light an aerial wire-rope is utilized to transport the boiler ash ; this is the first application of the aerial wire-rope way in the collieries in Japan. There are two screening houses one of which being used for the screening of the Eight-foot-seam and the Four-foot-seam coals and the other for the Nanaheda and Five-foot-seam coals. The former is equipped with a Briart bar-screen, a gyrating sieve and endless bands while in the latter case an Improved Briart bar-screen made in the Kōbukuro Workshop is used. The coals in the former screening house are sized to large block, small block and fine coal, and the blocks are subjected to hand picking on the bands separately while in the latter case the block and fine coal, and the block are treated on the band.

There are ten Lancashire and four Cornish boilers in which the four Lancashire have each a pressure of 70 lbs. per square inch while the remaining have 120 lbs. pressure. There are three generators of electricity of 100 kilowatts each and one of 160 kilowatts, the voltage being 250 volts. The number of labourers employed at the end of December 1908 was 2,442.

The annual production of coals for five years ending 1908 was:—

| | long tons. |
|---|---|
| 1904 | 205,170 |
| 1905 | 221,445 |
| 1906 | 244,262 |
| 1907 | 249,721 |
| 1908 | 290,979 |

In order to supply electric lamps in the labourers' houses a generator of electricity of 160 kilowatts will be set up within a short time in the future.

## HŌJŌ COLLIERY.

This colliery is situated on the south west of Kanada, a station of the Chikuhō line, the Kyūshū railway.

The coal seams occur in the Tertiary. There are three principal workable seams namely the Eight-foot-seam, the Three-foot-seam and the Tagawa-four-foot-seam. The former is actually worked while the latter two are not yet worked. The analysis of the Eight-foot-seam coal is as follows:—

| Moisture. % | Volatile metter % | Fixed carbon. % | Ash. % | Sulphur. % | Specific Gravity. |
|---|---|---|---|---|---|
| 2.42 | 26.98 | 67.80 | 5.22 | 0.37 | 1.28 |

There are two shafts of 896 feet 8 inches deep. The former has 14 feet 6 inches diameter and is used principally for transportation and as a downcast, while the latter has 18 feet diameter and is used for draining, transportation and as an upcast. The sinking of these shafts was started in March, 1902 and was finished in August 1905 for the one and in January 1908 for the other. The sinkings were facilitated by using No. B. Ingersoll Eclipse rock drills. According to the results of the use of the drills, the proportions of mechanical to hand drilling in the case of soft shale, hard sandstone and conglomerate were respectively $7\frac{2}{3}:5$, $24:5$ and $24:4$. Among the difficulties met with during the sinking of the shafts were the influx of water from the sandstone, at the depth of 313 feet flushing to the amount of 90 cubic feet of water per minute, and at the depth of 588 feet flushing at the rate of 50 cubic feet of water per minute, were the most troublesome ones, but they were conquered by the use of brick cofferings

This colliery is still in the course of preparatory works only producing 320 long tons of coals a day at the end of June 1909, but when the whole arrangements are completed its maximum daily production will reach 1500 long tons.

The present state may be briefly described as follows:—The coals are worked on the rising side for about 1,200 feet by the long-wall system making many engine planes of various capacities and on the dip side for about 2,400 feet by the striking long wall system making level tub ways at the intervals of 99—120 feet. The cutting of coal is facilitated by using Sullivan Puncher rock drills. All underground mine roads are equipped with rails. The ventilator used is a Walker Indestructible fan discharging 150,000 cubic feet of foul air per minute. The pumps set at the shaft bottom are two of Riedler's differential compound duplex pumps of 160 cubic feet per minute capacity and 900 feet lift.

The actual horse power in use is 2,464 and the number of labourers employed at the end of December 1908 was 1,188. The distribution of motive power is as follows:—

| | H.P. |
|---|---|
| Shaft winding | 1,604 |
| Pumping | 396 |
| Screening | 20 |
| Lighting | 70 |
| Endless rope | 153 |
| Ventilator | 110 |
| Compressor | 56 |
| Workshop | 43 |
| Miscellaneous | 10 |
| Total | 2,464 |

This colliery commenced to produce coal in 1908, the annual production of the year being 96,648 long tons.

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## THE HŌKOKU COLLIERY.

The colliery is situated 720 feet north of the Miyatoko station, on the Chikuhō line of the Kyūshū railway.

The coal seams occur in the Tertiary and there are two seams actually working namely the Eight-foot-seam and the Four-foot-seam. Besides the above there are three seams workable. The qualities of the coals can be judged from the following analyses :

| Name of seam | Moisture % | Volatile matter. % | Fixed carbon. % | Ash % | Sulphur. % | Specific gravity. | Calories. |
|---|---|---|---|---|---|---|---|
| Eight-foot-seam | 2.38 | 41.83 | 52 57 | 3.22 | 0.52 | 1.52 | 7,783 |
| Four-foot-seam | 2 41 | 39.33 | 50.52 | 7.74 | 0.33 | 1.27 | 7,447 |

There are two main slopes for transportation, three accessory upcast shafts and one slope for communication and as a downcast. This colliery is one of the most fiery mines in Japan. The ventilators use are one Sirocco fan on the Second shaft and one Capell in fan on the Third shaft having a gross discharging capacity of foul air of 150,000 cubic feet per minute. Besides them there is one Champion fan on the First shaft, for reserve. As mine lamps Evan Thomas, Ashworth, Hepplewhite-Gray and Clanny safety lamps are used and as officers' lamps a few Wolf magnetic locking safety lamps are also used . Underground conveyance is carried onby an endless-rope.

The coals are screened with a bar-screen and the block coal passing over the screen is subjected to hand-picking on the travelling band while the other part passed through the screen is sized again in punched sieves to small block and fine coal.

There are ten Lancashire and eight Cornish boilers, the nominal horse power being 1,700. The distributions of steam power is as follows :—

| | H.P. |
|---|---|
| Transportation | 728. |
| Generator of electricity | 580. |
| Screening | 17. |
| Workshop | 6. |
| Ventilator | 65. |
| Pumping | |

The number of labourers employed at the end of December 1908 was 1,454. This colliery suspended its work from June 1907 up to Feb. 1908 to repair the mine working destroyed by the violent underground explosion that occurred in June 1907. For that reason, the annual production of coals suddenly decreased since that year. The annual production of coals for five years ending in 1908 was :—

| | long tons. |
|---|---|
| 1904 | 191,200 |
| 1905 | 217,746 |
| 1906 | 214,730 |
| 1907 | 174,197 |
| 1908 | 127,084 |

The colliery is driving a main transportation slope to get a daily production of coals to the amount of 340 long tons, the excavation being facilitated by using rock drills. The driving was started in April 1909 and it will be finished in Oct. 1910. The colliery set up three generators of electricity of 100 kilowatts each, in order to actuate the underground pumps and endless-rope and they will be moved within a short time in future. A screening house having a capacity of treating 1,200 long tons of coals a day was built.

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## THE MITSUI-TAGAWA COLLIERY.

The colliery embraces three mines the Honkō, the Ōyabu and the Ita, and its office is in Honkō close by the Gotōji station, a station on the Hōshū line of the Kyūshū-railway. The Ita mine is also close by the Ita station of the same railway and the Ōyabu mine lies some 2,000 feet south-west of the Honkō.

The coal seams occur in the Tertiary. The seams actually worked are the Ita-eight-foot seam, the Tagawa-eight-foot-seam, the Three-foot-seam and the Tagawa-four-foot-seam. Among these seams the Ita-eight-foot-seam is on the top, 1,100 feet below the top seam lies the Tagawa-eight-foot-seam, 60 feet under the latter is the Three-foot-seam and 130 feet below the same lies the Tagawa-four-foot-seam; their average strike nearly coincides with the meridian and dips 11°—13° to east.

The qualities of these coals can be judged from the following table.

| Seams | Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Specific gravity. | Calorific power. |
|---|---|---|---|---|---|---|---|
| Ita-eight-foot | 1.550 | 44.200 | 46.817 | 7.433 | 0.290 | 1.304 | 7,480 |
| Tagawa-eight-foot | 2.747 | 37.383 | 55.780 | 4.090 | 0.999 | 1.331 | 7,370 |
| Three-foot | 2.700 | 36.775 | 55.160 | 5.365 | 0.365 | 1.431 | 7,480 |
| Tagawa-four-foot | 1.440 | 40.850 | 35.246 | 4.505 | 0.259 | 1.314 | 7,920 |

The mine openings, actually in use, are a main slope for endless rope, a slope for the miners communication, an upcast shaft in each mine and one other upcast shaft in the Honkō; the length of the main slope being 4,320 feet in the Honkō, 4,500 feet in the Ōyabu and 4,200 feet in the Ita mine. Besides the above mentioned opeings, there are two new shafts in the Ita, designed to obtain the daily production of 1,500 long tons of coal. They are both circular, the inner diameter being 18 feet in each; both sinkings were started on the 1st of June, 1905, and the First shaft struck the Tagawa-eight-foot-seam at the depth of 1014 feet in April 1909, while the second shaft reached the same at the same depth the next month; and at present both shafts are still continuing their sinkings to reach the lower seams or the Three-foot-seam and the Tagawa-four-foot-seam. To excavate these shafts, hand-drills and Little Wonder rock drills are used. Summarizing the effects during the sinkings, the progress of the bore holes in the sandstone per man per hour is 1.16 feet in the case of hand drilling, 4.3 feet in case of mechanical drilling; and in the shale 3.37 feet by hand drills; 4.3 feet by rock drills; from six to twelve rock drills being used at a time. Upon the lining foundation, made on the shaft wall at intervals of about 50 feet, concrete linings are generally made; but when much water flushes out brick linings are used and when the influx of water amounts to an enormous quantity coffering brick work is preferred; the rate of progress per 24 hours is 8 feet in the case of concrete, 6 feet in the case of common brick and 4 feet in coffering. To facilitate the draining during the sinkings, three Evan's sinking pumps for each shaft are used, each having a capacity of lifting 50 cubic feet of water per minute to the height of 350 feet, and after sinking about 300 feet a pumping station is cut in the shaft wall in which three duplex pumps each having a capacity of 100 cubic feet per minute are set. But after the sinkings are completed large pumps will be placed at the shaft bottom from which the mine water will be delivered with a single lift. Shaft frames are made of I-shaped steel and aresimpler in form than the ordinary type.

The coals are worked in the Honkō and the Ōyabu by the long-wall system, and in the Ita by the pillar and room system. With regard to underground pumping, in the Honkō electric three throw pumps are chiefly used, in the Ōyabu electric three throw pumps, steam duplex pumps and Special pumps, and in the Ita steam duplex pumps and Special pumps only are used.

All mines use endless-rope in underground passages along the main slope and on some levels.

The ventilators used are :—

| Mines. | Names. | Diameters. | Number. | Discharge of air in cubic feet. |
|---|---|---|---|---|
| The Honkō | Champion | 8′ | 1 | 73,000 |
| The Ōyabu | Guibal | 30′ | 1 | 47,000 |
| The Ita | Sirocco | 4′6″ | 1 | 150,000 |

Each mine is provided with a screening house eqipped with a set of movable bar screens having slits ¾ inches wide, a shaking riddle having holes punched 1 inch in diameter and two pairs of travelling picking bands. All blocks passing over and small sized coals passing through the bar screen are separately subjected to hand-picking on the travelling bands, while the fine coal passing through the riddle is sent directly to the market.

The motive steam powers actually used are as follows :—

| | H.P. |
|---|---|
| Shaft sinking | 150 |
| Transportation | 1,737 |
| Screening house | 30 |
| Draining | 2,664 |
| Ventilation | 99 |
| Generator of Electricity | 450 |
| Workshep | 12 |
| Miscellaneous | 45 |
| Total | 5,237 |

The number of labourers employed at the end of December 1809 were 4,460.

The annual production of coals during the five years ending 1908 was:—

| | long tons. |
|---|---|
| 1904 | 467,326 |
| 1905 | 420,002 |
| 1906 | 423,419 |
| 1907 | 479,204 |
| 1908 | 536,290 |

## THE MIYAZAKI-HŌSHŪ COLLIERY.

The colliery lies near by the Ikejiri station, on the Hōshū line of the Kyūshū-railway.

The coal seams occur in the Tertiary. In this region the andesite occurs here and there changing the coals to the metamorphosed or semicoked coals. There are five seams, namely, the Eight-foot-seam, the Three-foot-seam, the Four-foot-seam, the Upper-five-foot-seam and the Lower-five-foot-seam, but the latter two areof an inferior quality.

There are eight slopes and two shafts in which four of the former are main slopes for transportation and the remaining four are either upcast and draining ways or communication slopes.

The coal se ams are worked by both the pillar and room and the long-wall systems. Underground pumps are all Special pumps and there are twenty of them. The underground transportation is facilitated by four hauling engines hauling tubs on the main slopes.

There are five Lancashire and nine Cornish boilers. The number of labourers employed at the end of December 1908 was 929.

The annual production of coals for five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 64,410 |
| 1905 | 68,418 |
| 1906 | 77,610 |
| 1907 | 81,714 |
| 1908 | 106,002 |

## THE ŌTŌ COLLIERY.

The colliery lies close by the Kawasaki station, on the Hōshū line of the Kyūshū-railway.

The coal seams occur in the Tertiary and there are six seams in which four are being worked, namely, the Upper-four-foot-seam, Shakunashi-seam, Eight-foot-seam and Lower-four-foot-seam (semicoked coal), their strike being N 30° W, and the dip 15° NE.

The character of the Eight-foot-seam coal is as follows:—

| Moisture. | Volatile matter. | Fixed carbon. | Ash. | Sulphur. | Calories. |
|---|---|---|---|---|---|
| % | % | % | % | % | |
| 2.12 | 36.60 | 50.03 | 11.17 | 0.81 | 7,260 |

There is one main slope for endless transportation 6,496 feet long and one main hauling slope 3,696 feet long. Besides the above there are four accessory slopes.

The coal seams are worked by the pillar and room system on the upper part and by the long wall system on the dip part. For pumping thirty-one Special pumps and three miscellaneous pumps are used. The underground transportation is carried on by one hauling engine and one endless rope, and besides there are two transportation engines for miscellaneous use. The mine lamps in use are the Clanny and the Davy safety lamps. The screening house is equipped with a Briart bar-screen and a picking band and the coal are sized to block and fine coal, the block being subjected to hand picking. The steam power generators are twelve Lancashire boilers.

The number of labourers employed at the end of December 1908 was 1,305.

The annual production of the coals for five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 65,952 |
| 1905 | 127,298 |
| 1906 | 152,983 |
| 1907 | 155,898 |
| 1908 | 171,546 |

## THE KAIGUN-GOTOKU COLLIERY.

The colliery is situated two miles south of Nōgata, a station on the Chikuhō line of the Kyūshū railway.

The coal seams occur in the Tertiary and there are four seams capable of working, namely, the Kankan-seam 5.86 feet thick, the Three-foot-seam 6 feet thick, Shakunashi-seam 5.5 feet thick, and Five-foot-seam 5 feet thick, their strike changing from NEE to NNE and then to NNW and dips being from 5 to 18 degrees to SSE, SEE and NEE respectively.

All the mine openings are slopes and the coal seams are worked by the pillar and room system. There are ten Special pumps and eight Evan's pumps. The underground transportations are carried on by four hauling engines and one endless rope.

The power is generated by fourteen Lancashire boilers 6 feet diameter 28 feet long each.

The number of labourers employed at the end of December 1908 was 1,532. The annual productions of coals for the five years ending in 1907 were:—

| | long tons. |
|---|---|
| 1904 | 170,163 |
| 1905 | 152,423 |
| 1906 | 188,621 |
| 1907 | 216,421 |
| 1908 | 213,383 |

## THE MEIJI COLLIERY.

The colliery lies within two miles from the Kotake or Naka-idzumi station on the Chikuhō line, the Kyūshū railway, and embraces four mines namely the First, Second, Third and Fourth mine. The coal seams occur in the Tertiary and there are three seams actually being worked, namely, the Kankan-seam, the Three-foot-seam and the Five-foot-seam, the former two seams lying close to each other with a few partings while the latter are lying about 60 feet below them. Their strike varies from N 45° W to N 10° E and then to N 80° E, the dips being respectively 13° NE, 13° SE and 15° SE.

The qualities of coals of the colliery can be judged from the following analyses:—

| Names of seams. | Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Specific gravity. | Calories. |
|---|---|---|---|---|---|---|---|
| Kankan-seam | 2.990 | 40.400 | 52.518 | 3.855 | 0.237 | 1.272 | 7,590 |
| Three-foot-seam | 3.080 | 38.830 | 53.380 | 3.855 | 0.855 | 1.288 | 7,590 |
| Five-foot-seam | 2.175 | 42.505 | 52.996 | 1.945 | 0.299 | 1.252 | 7,810 |

Prospecting is done with several diamond borings. There are seven main slopes and one shaft for transportation; nine accessory slopes in which four are downcast and communicating ways, three up-cast and steam pipe ways and two downcast; and six accessory shafts, three of them being used for upcast and draining and the remaining three for steam pipe ways. Besides the above there is one level transportation way which is also used downcast and draining.

The coal seams are worked either by the pillar and room or by the long wall system.

Underground pumps in use are twenty Worthington duplex pumps, one Ideal pump and twenty-three miscellaneous pumps. The transportation in underground is carried on by one winding engine and five hauling engines, while in the open light it is facilitated by three endless-ropes. Besides the above there are two small engines for transportation.

The coals are sized either by bar-screens only or by mechanical screening. According to the latter method they are sized first by the bar-screens and trommels to large block, small block and fine coal and then the large block is subjected to hand-picking on the picking band.

There are forty Lancashire, three Cornish and two multitubular boilers, the total nominal H.P. being 4,191.5. The distribution of the steam power is as follows:—

| | H.P. |
|---|---|
| Transportation | 1,516.7 |
| Generator of electricity | 390.0 |
| Screening house | 24.4 |
| Workshop | 41.6 |
| Pumping | — |

There is one oil engine of 8 H.P. The number of labourers employed at the end of December 1908 was 3,186. The annual production of coals for five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 455,090 |
| 1905 | 425,932 |
| 1906 | 399,298 |
| 1907 | 388,663 |
| 1908 | 419,794 |

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## THE SHIOGASHIRA AND SHAKANO-O COLLIERY.

The colliery is situated one mile west of the Kotake station, on the Chikuhō line, the Kyūshū railway and embraces two mines namely the Shiogashira and the Shakano-o mines.

The coal seams occur in the Tertiary and there are twelve seams of which four are workable but two are actually worked, namely, the Four-foot-seam actually 6 feet thick and the Five-foot-seam actually 6.5 feet thick, their average strike being N 30° W and the dip 14° NE.

The qualities of the coals can be judged from the following analyses:—

| Names of seams. | Moisture | Volatile matter. | Fixed carbon. | Ash. | Sulphur. | Specific gravity. |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | |
| Four-foot-seam | 1.42 | 44.04 | 50.64 | 3 9 | 0.188 | 1.27 |
| Five-foot-seam | 0.70 | 44.92 | 51.98 | 2.4 | 0.182 | 1.25 |

There are two main slopes for transportation, two accessory slopes for communications and four accessory upcasts, one of which being a shaft and the remaining three slopes

The coals are worked by the pillar and room system. For ventilation one Champion fan of 98,00 cubic feet capacity and two Schiele fans of 55,000 cubic feet capacity each are used. The miners and officers' lamps in use are Clanny safety lamps and Cambrian pneumatic locking lamps. In this colliery the mine water to be pumped out of the mine amounts to from 200 to 360 cubic feet per minute, therefore comparatively large pumps are used. All the pumps are electric pumps except two Knowle's pumps. The pumps used are six Knowle's, two Deane and ten turbine pumps requiring a gross horse power of 1,500 in which two Knowle's pumps of 120 cubic feet capacity, 596 feet actual lift and 160 H.P. each and two Deane pumps of 120 cubic feet capatity, 540 feet actual lift and 225 H.P. each, are notable. The underground transportaion is carried on by one hauling engine and one endless-rope. Besides them there are two miscellaneous transportation engines and the gross horse power required for transportation is 540 H.P. The coals are sized with the grizzlies into block and fine coal, the block being subjected to hand-picking on the travelling hand in the Shakano-o mine.

There are twenty seven Lancashire and two Cornish boilers of 2,893 gross H.P. The electrical power is reduced from steam power and there are four generators of 200 kilowatts and 570 volts and one generator of 65 kilowatts and 2,705 volts.

The number of labourers employed at the end of December 1908 was 3,705.

The annual production of coals for five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 188,937 |
| 1905 | 168,415 |
| 1906 | 324,845 |
| 1907 | 339,296 |
| 1908 | 373,198 |

## THE NAMADZUTA COLLIERY.

This colliery lies on the east of Namadzuta, a station on the Chikuhō line of the Kyūshū railway.

The coal seams are found in the Tertiary, and six seams actually worked, namely, the six upper four seams named the Dōran-five-foot-seam, the Three-foot-seam, the Katagi-seam and Chirimen-five-foot-seam. The vertical distance between the fourth and the fifth seams and from the fifth to the sixth seams are respectively 300—400 feet and 20—30 feet. Their general strike is NS and the dip is 16° E.

There are five main slopes, namely the First Slope of 3,000 feet, the Third Slope of 3,300 feet, the Yanagi Slope of 2,000 feet, the Fourth Slope of 1,800 feet and the Fifth Slope of 70 feet.

The seams are worked by the pillar and room system. All underground pumps are turbine pumps except the Evan's steam pumps used in the First Mine. On the overground, the endless-rope of one mile between the First and the Third Mine and an electric railway between the Third and the Fourth Mine are set. This endless-rope will be replaced by an electric railway within a short time in the near future. The ventilators used are a Guibal fan in the First mine of 18 feet diameter discharging 80,000 cubic feet of foul air per minute and a Champion fan in the Third Mine of 6 feet diameter discharging 80,000 cubic feet of foul air per minute.

There are thirty one boilers in which four Babcock and Wilcox water tube boilers are embraced, eighty nine steam-engines of 1,410 H.P. and two Parson's turbo-alternators of 3,500 volts and 500 kilowatts each.

The number of labourers employed at the end of December 1908 was 2,207.

The annual production of coals for the five years ending in 1908 were as follows:—

| | long tons. |
|---|---|
| 1904 | 222,271 |
| 1905 | 214,035 |
| 1906 | 211,706 |
| 1907 | 230,695 |
| 1908 | 271,836 |

With regard to future developments one Parson's turbo-alternator of 3,500 volts and 500 kilowatts and two Babcock and Wilcox water tube boilers will be added in order to operate all engines, machines and locometives both underground and overground in the colliery.

## THE YOSHIO COLLIERY.

The colliery lies on the east of the Iidzuka station on the Chikuhō line of the Kyūshū railway and embraces two mines namely the Kamimio and the Yamanouchi mine.

The coal seams occur in the Tertiary and there are five seams actually worked, namely, the Three-foot-seam 3.6 feet thick, the Shakunashi-seam 3 feet thick, the Katagi-seam 6 feet thick with 0.4 feet partings, the Ōtake-seam and the Koishi-seam.

There are two main hauling slopes, two upcast and draining slopes and two downcast slopes for communication in the Kamimio mine; and three main hauling slopes, two upcast and draining slopes, one downcast shaft, one upcast shaft and one downcast slope for communications in the Yamanouchi mine. Besides the above there are thirteen small mine-openings for the working of the Ōtake and the Koishi semicoked seams. For ventilation a Champion fan of 10 feet diameter, while as mine lamps the Davy, the Clanny and the Wolf safety lamps are used. The underground pumps in use are nine Special pumps, eleven Evan's pumps and two small Worthington pumps in which eight Evan's 16 inch pumps are somewhat larger, the total mine water to be pumped being 172 cubic feet per minute. The underground transportation on the main slopes is carried on by five hauling engines. The coals are sized by fixed grizzlies to the block and fine coal.

The steam generators are eleven Lancashire, twenty five Cornish boilers and one vertical boiler. The number of labodrers employed at the end of June 1908 was 1,792.

The annual production of coals for five years ending in 1908 was :—

| | long ton |
|---|---|
| 1904 | 102,478 |
| 1905 | 127,295 |
| 1906 | 146,124 |
| 1907 | 218,497 |
| 1908 | 243,306 |

## THE FUTASE COLLIERY.

The colliery belongs to the Government Iron Works. It lies on west of the Iidzuka and Kōbukuro stations on the Chikuhō line of the Kyūshū railway and embraces two mines namely the Uruno and Takao mine. Besides the above there is one mine, actually sinking a new shaft called the Central Shaft.

The coal seams occur in the Tertiary and the workable seams number five, namely, the Sainome-five-foot-saem, four feet thick and lying 400 feet above the next seam; the Four-foot-seam, seven feet thick; the Kankan-seam, three feet thick; the Five-foot-seam five feet thick and lying 150 feet below the Four-foot-seam, and the Bottom-three-foot-seam 200 feet below the Five-foot-seam. Their strike nearly coincides with the meridian and the dip is 14°—16° E.

For prospecting twenty diamond borings were made using the No. N Sullivan diamond boring machine There is one main hauling slope and one main slope for the endless wire-rope system of transportation in the Takao mine, and one main hauling slope, one main winding shaft 460 feet deep, and one main underground slope for the endless rope system of transportation in the Uruno mine. The coal seams are worked either by the pillar and room or by the long-wall system. For ventilation, one Capell fan of 7 feet diameter and one Champion fan of 8 feet diameter in the Takao mine and one Canell fan of 7 feet diameter in the Uruno mine are used, the safety lamps in use are to the Davy and the Clanny. The mine pumps in use are nineteen electric pumps in which nine Express pumps of 40 cubic feet capacity and 600 feet lift each and two turbine pumps of 70 cubic feet capacity and 700 feet lift each and twelve steam pumps. The coals are sized with ehe Briart bar-screen and subjected to hand picking on the travelling band.

In the central power station there are four Babcock and Wilcox water tube boilers, two Cornish boilers, six Lancashirs boilers and two Parson's steam turbines. The number of labourers employed at the end of December 1608 was 2,629.

The coal production for five years ending in 1908, was :—

| | long tons. |
|---|---|
| 1904 | 242,434 |
| 1905 | 278,001 |
| 1906 | 344,450 |
| 1907 | 364,136 |
| 1908 | 354,936 |

The colliery, as before mentioned, is sinking the Central shaft of 17.15 feet diameter, that is designed to produce 2,000 long tons of coal daily. The sinking was started in August 1906 and it will end in 1910 after sinking 1200 feet. The depths reaching the Four-foot-seam and the Five-foot-seam are respectively 1,000 and 1,150 feet. To facilitate the sinking excavation Little Wonder rock drills are used, 70 bore holes being simultaneously blasted by electric firing. According to the design, three intermediate pumping stations will be made in the shaft at the intervals of 300 feet in depth and each station in active service will be equipped with two Weise Monski electrical-driven high-lift centrifugal pumps of 75 cubic feet capacity and 660 feet each one of which being left for reserve. The sinking pumps in use are two of the same type of 35 cubic feet capacity and 330 feet lift, but after sinking, pumps of the same type, having 350 H.P. will be set at the shaft bottom, by which the mine water will be delivered with a single lift.

In the central power station one Babcock and Wilcox water tube boiler, one accessory chimney of 12.7 feet diameter and Parson's steam turbine generating 1,000 kilowatts of electric power will be set up as the power generators in the New Mine.

For the winding of the Central Shaft, two winding engines and two pairs ef cages will be arranged, one pair of the latter having a pair of double-decked cages loading four tubs each while the other common cages load two tubs each. The screening of coals in the new plant will be carried on according to the double-unit system and the screening house, therefore, will be equipped with two pairs of two tipplers, swinging screens and picking tables. A ware house for coal will be made, the width and length being respectively 148.5 feet and 511.5 feet with a storage capacity of 10,000 loong tons of the first class coals and 1,000 long tons of the Second class. The designed coal tubs will be made of iron and will have self-lubricating attachments. The underground transportation will be carried on by the present endless rope system in the Uruno mine at first, but in the future an endless rope arranged according to the twin-hauling system with self-acting planes on rises will be applied. The ventilator to be used is a Rateau fan having high efficiency in a mine of small equivalent orifice.

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## THE TADAKUMA COLLIERY.

The colliery lies on the south-west of the Iidzuka station, on the Chikubō line of the Kyūshū railway.

The coal seams occur in the Tertiary and there are nine seams in which four are workable; namely the Koishi-three-foot-seam 3.1—

3.5 feet thick lying 464 feet below the top seam ; the Five-foot-seam actually 6.7 feet thick lying 60 feet below the former ; the Lower-three-foot-seam 3 feet thick lying 310 feet below the Five-foot-seam, and the Four-foot-seam 5.1 feet thick lying 21 feet below the Three-foot-seam. The Five-foot-seam is worked principally. Their strike is N33°—39° W and the dip 20° NE.

The analysis of the Five-foot-seam coal is as follows :—

| Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Specific gravity | Calories |
|---|---|---|---|---|---|---|
| 1.91 | 41.29 | 53.71 | 2.75 | 0.34 | 1.258 | 7,920 |

For prospecting, diamond borings were used. There is one main slope for endless transportation 5,100 feet long, and one main hauling slope 1,900 feet long. The coals are worked by the pillar and room, the long-wall or the double-road-stall systems. The ventilators in use are one Champion fan of 104,400 cubic feet designed capacity, and one Capell fan of 200,000 cubic feet designed capacity. The mine lamps in use are the Davy safety lamps and the Wolf magnetic locking safety lamps. For pumping, three Knowle's tandem compound duplex pumps of 100 cubic feet and 550 feet lift each, four small Worthington pumps and two Knowle's pumps of the smaller type are used. The underground transportation on the main slopes is carried on by one hauling engine and one endless rope. On open lights the conveyance is facilitated by one endless-rope. The screening house is equipped with the Briart bar-screen, trommels and picking endless bands. The coals are sized by the bar-screen and trommels into the sizes, large block, small block and fine coal, and the block sizes are separately subjected to hand picking on the endless bands. There are twelve Lancashire and two Cornish boilers.

The number of labourers employed at the end of December 1908 was 1,697. The annual production of coals for five years ending in 1908 was :—

| | long tons. |
|---|---|
| 1904 | 168,869 |
| 1905 | 147,845 |
| 1906 | 123,047 |
| 1907 | 61,331 |
| 1908 | 168,959 |

The decrease of production in 1907 was due to the underground fire, that broke out on the 17th in April of the same year. Within a short time in future, Weise Monski electric turbine pumps and their accessory engine and generator of electricity will be set up.

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## THE MAMEDA COLLIERY.

The colliery lies on the south-west of the Nagao station on the Chikubō line of Kyūshū railway.

The coal seams occur in the Tertiary and there are four seams actually worked, namely, the Upper-five-foot-seam actually 4.1 feet thick with a 0.2 feet parting, the Lower-five-foot-seam actually 3.3 feet thick with a 0.7 feet parting, the Lower-eight-foot-seam actually 4.5—6.5 feet thick with a 0—0.3 feet parting and the New-eight-foot-seam 7.2 feet thick with a 1.3 feet parting.

There are three main hauling and communication slopes, their lengths being respectively 3,516, 2,886 and 522 feet, and three upcast and dressing slopes. In the underground workings the local fans are used for local ventilation. The mine pumps in use are fourteen Evan's pumps and one Special pump, among them five former pumps are somewhat larger. The underground transportation is carried on by three hauling engines, while in the open light an endless rope is utilized. The screening house is equipped with Briart bar-screen and endless bands, the coals being sized by the former two to the large block, small block and fine coal; and the blocks are subjected to hand picking on the bands separately, while the fine coal is sent to the washing.

The steam generators are thirteen Lancashire boilers. The number of labourers employed at the end of June 1908 was 1,076.

The annual production of coals for the five years ending in 1908 was :—

| | long tons. |
|---|---|
| 1904 | 68,971 |
| 1905 | 99,378 |
| 1906 | 104,856 |
| 1907 | 137,894 |
| 1908 | 150,178 |

## THE MITSUI-YAMANO COLLIERY.

The colliery lies on the south-east of the Iidzuka station, on the Chikuhō line of the Kyūshū railway.

The coal seams occur in the Tertiary and there are four seams actually working namely the Yamano-eight-foot-seam, the Yamano-five-foot-seam, the Uryū-eight-foot-seam and the Gamō-five-foot-seam. Their strike nearly coincides with the meridian and the dip is 9°—24° E.

The qualities of the coals can be judged from the following analytical table :—

| Names of seams. | Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Calories. |
|---|---|---|---|---|---|---|
| Yamano-eight-foot-seam | 2.99 | 44.38 | 46.04 | 6.59 | 0.72 | 7,260 |
| Yamono-five-foot seam | 3.06 | 41.13 | 49.03 | 6.78 | 1.00 | 7,150 |
| Uryū-eight-foot-seam | 2.10 | 39.86 | 52.76 | 5.28 | 0.46 | 7,095 |
| Gamō-five foot-seam | 2.647 | 39.55 | 52.18 | 5.62 | 0.84 | 7,315 |

Prospecting is done with two American rope borings. There are five main transportation slopes namely the Yamano First, Second, Third, Gamō and Uryū Slope. The coals are worked either by the pillar and room or by the long-wall system. There are two Champion fans 8 feet in diameter and of 70,000 cubic feet capacity each. For pumping five duplex pumps and fifty three Special pumps are used. The transportation is carried on by five hauling engines and one endless rope. The screening house is equipped with the Briart bar screen, gyrating riddle and endless picking bands, the coals are sized by the former two into the sizes of large block, small block and fine coal and the blocks are subjected to hand picking on the bands separately. The power generators are twenty five Lancashire and four Cornish boilers, while at present a central electric power station is in process of erection. The number of labourers employed at the end of December 1908 was 2,320.

The annual production of coals for five years ending in 1908 was :—

| | long tons. |
|---|---|
| 1904 | 179,136 |
| 1905 | 221,224 |
| 1906 | 125,754 |
| 1907 | 139,059 |
| 1908 | 177,694 |

Within a short time in the future, coal winning on the long wall face will be facilitated by utilizing coal-cutters.

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## THE SHIMOYAMADA COLLIERY.

The colliery lies close by the Shimoyamada station, on the Chikuhō line of the Kyūshū railway.

The coal seams occur in the Tertiary and there are thirteen seams of which two are actually worked, namely the Kaigun-eight-foot-seam 6.1 feet thick and the Kōmori-five-foot-seam 6.4 feet thick, their average strike being N 50° W and the dip 21° NE. The andesite occurs here and there in the forms of dykes and sills altering the Eight-foot-seam to metamorphosed coal or semicoked coal.

The qualities of the coals can be judged from the following analyses :—

| Names of seams. | Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Specific gravity. | Carbon. |
|---|---|---|---|---|---|---|---|
| Kōmori-five-foot-seam | 1.48 | 40.42 | 55.27 | 2.82 | 0.48 | 1.30 | 7,400 |
| Kaigun-eight-foot-seam | 3.10 | 38 52 | 55.67 | 2.81 | 0.74 | 1.31 | 7,600 |

There are two main slopes for transportation 2,100 and 600 feet long respectively, three accessory upcast and one slope for communication.

The coals are worked either by the pillar and room or by the long wall system. Underground pumps in use are thirteen Special pumps requiring 285 H.P. together, but in 1909 two Worthington pumps of 80 cubic feet per minute capacity and 350 feet lift and two Evan's pumps of 60 cubic feet per minute capacity and 350 feet lift will be set up and be put in use in the earlier half of 1910. The underground lamps in use are the Davy, the Clanny and the Cambrian safety lamps, the gas testing lamps being Chesneau lamps. The underground transportation is carried on by one steam hauling engine and one electric hauling engine while in the open light an endless-rope is utilized. The coals are sized by grizzlies only.

There are ten Lancashire boilers of 996 H.P. together, and one generator of electricity of 80 kilowatts and 550 volts moved by steam powers. The number of labourers present at the end of December 1908 was 1,103.

The annual production of coals for five years ending in 1908 was :—

| | Coals long tons. | Metamorphcsed coals. long tons. |
|---|---|---|
| 1904 | 70,357 | 0 |
| 1905 | 64,504 | 0 |
| 1906 | 103,449 | 3 |
| 1907 | 119,878 | 33 |
| 1908 | 105,336 | 0 |

The sinking of the main slope and the accesrory slope in the Second mine was started from the end of 1908 and it will finish the sinking and all its accessory works in June 1910 ; by that new mine the colliery will get a daily production doubling that of the present day. And in order to get better communication and transportation, 900 feet of tunnel was excavated between the new mine and the First mine, also an endless-rope was between the same mines which is at present making trial trips between the two mines.

## THE MIIKE COLLIERY.

The colliery office is at Ōmuta, a station on the Kagoshima line of the Kyūshū railway. The whole concession covers the vast area of 15,145 acres, under which the presence of coal had been already proved by the diamond and Calix borings.

The colliery embraces six mines, their relative position may be stated as follows:—

On the south-east of the office lies the Miyanoura mine, on the east and south-east of the latter is respectively the Ōura and the Nanaura mines, on the south-east and south-west of Nanaura are respectively the Kachidachi and the Miyanoharu mines and on the south-west of the latter lies the Manda mine a little apart. The distance between the office and the nearest mine Miyanoura is 71 chains and the remotest Manda is 2 miles and 25 chains.

The coal seams occur in Tertiary strata. The seams worked at present are the first seam or the Eight-foot-seam and the second seam about 5 feet in thickness or the Banshita-seam lying 6 to 10 feet below the first, but the latter is limited to the Ōura mines only. For the reason that the first seam bears a thick sandstone stratum on its roof and the water zone on the upper level is about 100 feet above, the influx of water in the Miike mine workings is enormous; but the occurrence of fire-damp is very rare. The general strike of the stratification is N 13° W and dips 5° to SW. The characteristics of the Miike coal are its strong caking property, its high calorific power and homogeneous structure throughout the whole seam due to the scantiness of its shaly partings, the analysis of it is as follows:

| Moisture. | Volatile matter. | Fixed carbon. | Ash. | Sulphur. | Specific gravity. | Calorific power. |
|---|---|---|---|---|---|---|
| | % | % | % | % | | |
| 0.350 | 40.100 | 53.217 | 6.333 | 2.282 | 1.275 | 8,140 |

In the six mines of the colliery the Ōura is working the outcrop region the north-west corner of the whole concession, while the Kachidachi works from the outcrop to the deeper fields on the east, the western part of the Kachidachi being the dip side of the Ōura; the

Nanaura lies on the southern deeper side of the Ōura, having the Miyanoura on its north-western strike and the Kachidachi deeper workings on the south-eastern strike; on the dip sides of the Miyanoura and the Nanaura lies the Miyanoura, the eastern strike side of which being also close by the Kachidachi deepest part; at present the Manda is working the field lying on the dip side of the Miyanoharu, but the mine has a huge coal field extending 5 miles along its strike.

The mine openings actually in use, the lengths of the main slopes and the approximate daily output of these mines are as follows:

In the Ōura mine there are a main hauling slope of 10 foot wide and 6 feet high, a main endless rope slope 14 feet wide and 6 feet high, both being used for the transportation of coals and as downcast, two slopes for miners communication parallel to the above two, one upcast shaft and one downcast shaft, the length of the main hauling slope being 2,200 feet and that of the main endless rope 1,900 feet. The approximate daily output of the mine is 550 long tons.

In the Nanaura, there are one main shaft of 14 feet diameter, 237 feet depth, used for winding coals, the delivery pipes and as downcast, and one upcast shaft for pipes, the length of the main slope or the eastern third slope being 900 feet. The approximate daily output is 640 long one.

In the Miyanoura, there are one rectangular main shaft of 12 feet × 18 feet section and 176.7 feet depth used for winding coals and as downcast and one upcast in Nanaura called Nanaura third slops the lengths of the main slopes of the western third slope and western fifth slope being respectively 4,000 feet and 2,600 feet. The daily output is about 840 long tons.

In the Kachidachi, there are two shafts, one main shaft similar to that of the Miyanoura, of 391.5 feet depth used for winding coals, pumping and as downcast; and one upcast shaft also used for pipes. The length of the main slope Nishi-San-Oroshi being 4,200 feet. The daily output is about 970 long tons.

In the Miyanoharu there are one main shaft of 23 feet diameter, 468 feet depth used for winding coals, pumping and as a downcast; and one upcast shaft used for pumping and the communication of men and horses; the length of the main slope or the western fourth slope being 2,900 feet. The daily output is about 780 long tons.

The Manda Mine lies on the dip side of the Miyanoharu workings 4,770 feet apart. There are two large rectangular shafts, one of which is named the Honkō, the main shaft, having 12 feet × 41 feet section and being 946 feet in depth; that struck the eight-foot seam in 1902, started its winning the next year and is used for winding coals in two pairs of cages, as a downcast and for pumping with four Davey's pumps. The other shaft having 12 feet × 27.5 feet section and 880 feet in depth is used for the winding men, horses and other materials and as an upcast. The length of the main incline, the western third slope, is 2,000 feet. The daily output is about 1,230 long tongs.

The method of the working of the coal is by the pillar and room system and the coal cutting is effected almost entirely by manual labour, but at present a course of examinations is going on as to the use of the Radialax and the Westphalian coal cutters. The excavations of mine workings such as pumping stations, engine rooms, stations for machinery and cross cuts through faults or barren strata, are facilitated by using Little-Wonder rock drills.

Formerly, in case of working pillars, the roof was supported by many cribs, but in 1908 an examination of the calm flushing by filling the goaf with sand and slime was tried on a portion covering 5,000 square yards under the railway line, and as the result was very favourable, a still more complete method is in the course of application in the Miyanoura mine, using, as materials, a mixture of boiler ash, sand and debris dredged from the Miike harbour, crushed to similar grains by fine crushers. According to the above mentioned examination, one part of flushing material mixed with four parts of water was charged, the quantity of water added being 40 cubic feet per minute; and 5 inch pipe of 2,050 feet long and 1 : 12.3 inclination and 6 inch pipe of 1060 feet long and 1 : 41.4 inclination were used as the means to guide the flushing fluid. With such an arrangement, a goaf of 5,000 square yards and 7 feet high was filled up in 375¾ hours.

In this colliery, the influx of mine water is, as before mentioned, enormous, and is estimated at 1,300 cubic feet per minute, i.e. 52,000 long tons per 24 hours, corresponding to about 10 long tons water per long ton coal produced. Accordingly, in this colliery, many high duty pumps of various types are utilized and the draining arrangements are said to be the most notable ones in Japan. The pumps used in six mines are briefly denoted as follows. In the Nanaura three Worthington 24″—40″ × 15″ × 3′ compound duplex pumps, four smaller pumps of the same type, one Evan's 24″—44″ × 16″ × 3′ compound duplex pump and one 21″ Special pump are used, the total actual H.P. necessary being 2,054 H.P.

In the Miyanoura mine two Davey's 7″ × 14″ × 4′ hydraulic duplex pumps, four Schleifmühle electric driven coupled pumps, one Schleifmühle electric single crank pump, one Gwyne 6″ two stages centrifugal pump, one Inokuchi's 7″ centrifugal pump, two Sulzer 7″ turbine pumps and four 6½″ × 7″ portable three throw pumps are used, the total H.P. necessary being 842.

In the Kachidachi Mine, one Davey's 40″—76″ × 24″ × 10′ differential pump, one Worthington 24″—40″ × 15″ × 3′ compound duplex pump, two smaller pumps of the same type, one Jeanesville 20″—30″ × 9½″ × 2′ compound duplex pump and three 8″ × 8″ electric three throw pumps are used, requiring 1,833 actual H.P.

In the Miyanoharu mine, one Davey's 45″—76″ × 30″ × 10′ differential pump, three Davey's 40″—76″ × 24″ × 10′ differential pumps, three Worthington 15″—20″ × 15″ × 15″ compund duplex pumps, two smaller pumps of the same type, three 21″ Special pumps are used, requiring 2,688 actual H P.

In the Manda mine, three Davey's 45″—90″ × 22″ × 12′ differential pumps, one Davey's 45″—76″ × 22″ × 10′ differential pumps, four Jeanesville 23″—60″ × 16″ × 4′ compound duplex pumps four Knowle's 13″ × 12″ electric three throw pumps, one Schleifmühle $6\frac{9}{16}$″ × $11\frac{13}{16}$″ electric driven coupled pump, three Sulzer 10″ turbine pumps, two Sulzer 12″ turbine pumps, thirteen 9″ × 10″ electric three throw pumps and one 4½″ × 5″ electric three throw pumps are used requiring 8,941 actual H.P.

Summarizing the above mentioned pumps there are two hydraulic pumps requiring 260 actual H.P., thirty-three steam pumps requiring 14,101 actual H.P. and forty-one electric pumps requiring 2,002 H.P.; among the steam pumps there are included nine Davey's pumps, twenty compound duplex pumps and four Special pumps and similarly among the electric pumps there are thirty-two electric plunger pumps and nine electric centrifugal pumps. The details of the specially notable pumps among them are as follows:—

| S.S. H.-L. × P. × S. | Names. | Types. | St. or El. | A.L. | Q. | H.P. | N. | T.H.P. |
|---|---|---|---|---|---|---|---|---|
| 24"-40" × 15" × 3' | Worthington. | Compound duplex. | St. | 230 | 250 | 337 | 2 | 674 |
| 24"-44" × 16" × 3' | Evan. | ,, | ,, | 245 | 300 | 370 | 1 | 370 |
| 7" × 14" × 4' | Davey. | Hydraulic duplex. | ,, | 164 | 180 | 130 | 2 | 260 |
| 6$\frac{9}{16}$" × 11$\frac{13}{16}$" | Schleifmühl. | Electric driven coupled. | El. | 164 | 100 | 58 | 3 | 174 |
| | 6" Gwyne. | Two-stages centrifugal. | ,, | 50 | 100 | 40 | 1 | 40 |
| | 7" Sulzer. | Turbine. | ,, | 156 | 100 | 70 | 2 | 140 |
| 40"-76" × 24" × 10' | Davey. | Differential. | St. | 410 | 300 | 510 | 1 | 510 |
| 24"-40" × 15" × 3' | Worthington. | Compound duplex. | ,, | 450 | 250 | 339 | 1 | 337 |
| 45"-76" × 30" × 10' | Davey. | Differential. | ,, | 520 | 350 | 682 | 1 | 680 |
| 45"-90" × 22" × 12' | ,, | ,, | ,, | 944 | 300 | 1,027 | 3 | 3,081 |
| 22"-60" × 16" × 4' | Jeanesville. | Compound duplex. | ,, | 930 | 300 | 904 | 4 | 3,616 |
| | 10" Sulzer. | Turbine. | El. | 105 | 200 | 100 | 3 | 300 |
| | 12" Sulzer. | ,, | ,, | 102 | 200 | 145 | 2 | 290 |

Where S.S. =Diameter of steam cylinder or high pressure water cylinder.
H. =Diameter of high pressure steam cylinder.
L. =Diameter of low pressure steam cylinder.
P. =Diameter of plunger.
S. =Length of stroke.
S.T. =Steam power.
E.L. =Electric power.
A.L. =Actual lift.
Q. =Quantity of water delivered per minute in number of cubic feet.
H.P. =Actual H.P. necessary for one pump.
N. =Number of pumps.
T.H.P =Total actual H.P.

There are nine shaft winding engines as follows :—

In the Nanaura mine one that is of 20" steam cylinder diameter and 338 actual H.P.; in the Miyanoura one of 15" diameter and 218 H.P.; in the Kachidachi first shaft one of 24" diameter and 482 H.P.; in the Kachidachi second shaft one of 18" diameter and 190 H.P.; in the Miyanoharu first shaft one of 24" diameter and 534 H.P.; in the Miyanoharu second shaft one of 22" diameter and 432 H.P.; in the Manda first shaft two sets of 24" diameter and 766 H.P.; and in the Manda second shaft one of 22" diameter and 432 H.P.

On the main mine-ways, rails of 14—24 lbs weight per yard are thoroughly laid, the gauge being two feet in the Manda and 18½" in the other mines.

In the Manda iron tubs having a loading capacity of 1,433 lbs. of coal are in use, and in the other mines wooden tubs of 1,000 lbs. capacity are used. To draw the tubs on short level ways underground horses are employed, but as the drawing distance becomes remoter wire-rope transportation is practiced. There are three kinds of the latter e.i. (a) the self-acting, (b) hauling and (c) endless transportation, the former two being used on sloping ways and the third on level-ways; the motive powers of hauling and endless-rope transportation are steam and electric power. Besides the above, in some mines, near the shaft mouth or bottom, creepers are set in order to lift the tubs to some required higher levels. In the Manda mine in the underground passages four electric-locomotives are used in order to facilitate the conveyance on long level ways which will be prolonged to 5 miles in the near future, one locomotive drawing 30 tubs at a time with the velocity of 6 miles per hour.

The engines used for the above mentioned transportation are as follows. In the Ōura, two electric endless rope engines of 60 actual H.P., one electric hauling engine of 25 H.P. and one steam endless-rope engine of 82 H.P. are used. In the Miyanoura, two electric endless-rope engines (the one of 60 H.P. and the other of 30 H.P.); two electric hauling engines of 20 H.P. and one steam hauling engine of 41 H.P. are used. In the Nanaura, one electric endless-rope engine of 60 H.P. and a creeper near the shaft mouth are used. In the Kachidachi, three electric endless-rope engines, two of which being 30 H.P. and the other 60 H.P.; two steam endless-rope engines (the one is 180 H.P. and the other 55 H.P.); and a creeper near the shaft mouth are in use. In the Miyanoharu, one electric endless-rope engine of 30 H.P. and three steam eneless-rope engines of 38.5 and 270 H.P. are in use. In the Manda, six electric endless-rope engines four of which being 20 H.P. each and the remaining two being 40 and 75 H.P., one electric creeper of 10 H.P. near the shaft bottom, one electric creeper of 5 H.P. near the shaft mouth and four electric locomotives are used.

As the colliery has a widely expanded underground working field, barriers are left between workings of the six before mentioned mines, in order to limit the sphere of any possible accidents, and at the same time the ventilation of each mine is restricted to that individual mine by setting a ventilator to every mine. The fans used are as follows.

In the Ōura mine one Champion fan of 6 feet diameter discharging 70,000 cubic feet of foul air per minute; in the Miyanoura mine also, one Champion fan of 8 feet diameter and 95,000 cubic feet, one Sirocco fan of $24\frac{7}{8}''$ diameter and 10,000 cubic feet and two centrifugal local fans of $18\frac{1}{2}''$ diameter and 3,000 cubic feet; in the Nanaura mine one Guibal fan of 30′ diameter and 96,000 cubic feet and one Sirocco fan of the same size as that of the Miyanoura mine; in the Miyanoharu mine, one Sirocco fan of 40″ diameter and 81,000 cubic feet; in the Kachidachi mine, one Guibal fan of 30 feet diameter and 120,000 cubic feet and three local fans of the same size as that of the Miyanoura mine; in the Manda one Walker fan of 20 feet diameter and 130,000 cubic feet and three local fans of the same size as those of the Miyanoura and the Kachidachi are used. Among these fans the Guibal fans, the Walker fan and Sirocco fans in the Miyanoharu are moved by steam power while the others are rotated by electric power.

Generally there is no fire-damp in the underground passages in this colliery, so that in all mines naked lights are in use except the Manda mine and some parts of the Kachidachi, where although rarely a trace of fire-damp is sometimes found and the miners use Clanny safety lamps.

All mines, except the Ōura, have a screening house close by the main shaft mouth, the coals from the Ōura mine being sent to the Nanaura screening house by an air-line endless-rope. The coal tubs, inserted in the tipple on the top floor of the screening house, are overturned and the coals in the tubs fall on the movable bar screen. Close under this bar-screen Cox's gyrating riddle is set. The block coal above 2″ size passing over the bar screen and middle sized coal from $1\frac{1}{4}''$ to 2″ size passing through the same are separately subjected to hand picking on the pairs of travelling bands, while one part of the small sized coal and fine coal passing through the riddle is subjected to the wet dressing to form material for making coke and the other part is sent directly to the market.

About the overground transportation there is nothing specially worthy of mention, except the Miike harbour, for the reason that the branches of the Kyūshū line are prolonged to spaces under the bottom of the screening houses, where waggon-trucks on the railway are charged with coals directly from the floor, ready for transportation by the company's locomotives.

There are two kinds of boilers in this colliery one of which is of the Lancashire type and the other of the water tube style. The former boilers are eighteen boilers eight feet three inches in diameter and 30 feet in length, seventy-two boilers eight feet in diameter and 30 feet in length, eight boilers seven feet in diameter and 30 feet in length, one boiler six feet six inches in diameter and 30 feet in length, the total number amounting to one hundred and seven. And the latter water-tube boilers are ten Starling boilers having a heating surface of 4,200 square feet each, four Babcock and Wilcox boilers of 4,113 square feet heating surface each and six Babcock and Wilcox boilers of 4,510 square feet heating surface each.

The generators of electricity are five Curtis turbogenerators, the amount of electricty generated and voltage are respectively 1,000 kilowatts and 2,300 volts each.

The motive powers used are:

| | H.P. |
|---|---|
| Winding and hauling | 4,178 |
| Transportation except winding and hauling | 1,617 |
| Draining | 16,363 |
| Ventilation | 620 |
| Screening house | 320 |
| Workshop | 302 |
| Total | 24,958 |

in which 20,360 H.P. being steam power directly used and 4,338 H.P. and 260 H.P. being respectively electric and hydraulic powers reduced from steam power.

The number of labourers present at the end of December 1908 was 9,976.

Ths annual production of coal for the five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 1,236,638 |
| 1905 | 1,301,126 |
| 1906 | 1,455,469 |
| 1907 | 1,474,523 |
| 1908 | 1,513,389 |

There are many works especially noticed in the colliery; among them the most distinguishing ones are the large Manda shafts and their accessory arrangements; the Miike harbour and the Mitsui dock; the application of electricity, both in the underground workings and in the open air, and the application of the Calix boring machine.

But the details about the Manda shaft and its accessory arrangements have already been generally described, so that they will be omitted here. About the Miike harbour and Mitsui dock the details are illustrated as follows.

Formerly, the Miike colliery was loading 4,000 long tons of coal per 24 hours using the Yokosu pier on the coast, west of the Ōmuta station. But to export coals there was an inconvenience involving the sending of the coals to Kuchinotsu port once before shipment abroad on board vessels there. Moreover the output of the Manda mine was increasing more and more to such an extent that the small Yokosu pier could not handle all the Miike output of coal. For these reasons, in order to export much coals abroad directly by economical means, near Yotsuyama, on the south of Ōmuta station about two miles apart, a large dock and a harbour building works were started by the Mitsui Firm by their own capital in 1903, and they had nearly finished the works in 1907, naming them the Miike harbour and the Mitsui dock. The site is in Mikawa village, Miike county, in the southern extremity of Chikugo province, bordering on the Ariyake Bay in the latitude of 33° 00′ 14″ N, longitude 130° 23′ 10″ E, and is only 33 nautical miles distant from Kuchinotsu. The Miike harbour comprises the water area within the arc of a circle drawn with the light house on the extreme point of the north jetty as a centre, the circle having a radius of one and a half nautical miles, and may be divided into three sections:—the outer harbour, the inner harbour, passage and the wet dock. The outer harbour is the water area within the harbour limits exclusive of the inner harbour and the dock. The inner harbour, bounded by the break waters and seawalls of the dock-yard, has a total area of about 124 acres. At present, a channel course across the central part of the inner harbour and some anchorage space has already been dredged out. When the entire dredging is completed, the northern half of the inner harbour will be appropriated exclusively for the public use. The two breakwaters bounding the inner harbour, are each about 3,000 feet long and the top of the wall is three feet above the high water level and the width is 15 feet. The passage channel, 6,000 feet long extending from the inner harbour to the outer, has a minimum depth of 18 feet at the lowest low-water level. It is protected from the waves and the intrusion of silt by means of two parallel jetties on both its sides. These jetties are similar in structure to those of the break waters having a height of one foot above high-water level and a breadth of 12 feet. The distance between the two jetties, measuring from centre to centre, is 450 feet. At present, a water course, 150 feet wide at the bottom and 18 feet in depth at the lowest ebb is already dredged out, but in the future, it may be widened out to about 250 feet, so as to enable vessels to pass each other. For the convenience of shipping at night, the entrance to the inner harbour is shown by an occulting light (white and red) from the light house.

The wet dock is under the exclusive control of the Mitsui Firm and will be used principally for coal loading. It has a surface area of 32 acres at high-water level and the depth of water is constantly kept not less than 28 feet by means of lock gates, being capable of accommodating eight or nine vessels at the same time. The quay-wall which is 1,380 feet long, 41 feet 6 inches high is situated at the eastern extremity of the dock and is sufficiently large for the simultaneous accommodation of three vessels of 8,000 tons. On the quay-wall are at present installed two sets of Patent Miike loading skips, designed by director Dan and engineer Kuroda, to move laterally along the wall to provide a loading capacity of upwards of 10,000 long tons of coals per day, which is about double the present total output of the Miike coal mines. The dock gates, being controllers of the water level in the dock, form the most important part of the works. The width of the passage is 66 feet. The gates weigh 30 long tons each and are worked by means of hydraulic power. An iron pier, 300 feet long and 75 feet wide, is constructed along the southern side of the dock for the accommodation of vessels carrying general cargo. Coal storage yards are amply provided adjoining the quay-wall. The five rows of trestles are built upon five brick tunnels, in each of the latter electric railway tracks are laid for the loading and the transport of coal from the storage above. These specially equipped piers have an aggregate storage capacity of about 50,000 long tons, and are used chiefly for block coal.

The details referring to the application of electric power are as follows.

The application of electricity has been gradually developed since the first application in June 1901 in this colliery and in 1906 three Curtis steam turbo-generators of 1,000 kilowatts each were set up in order to utilize the electric power both underground and overground. And now two more of the same generators recently bought are in the process of being set up. Using the electric power generated by these generators, all the engines and machinery in the colliery will be moved by electricity, restricting the utilization of the direct steam power to the shaft bottoms. The present state of its application is as follows.

In the Ōura the steam power plants are being replaced by electric power; in the Miyanoura all the engines and machinery of transportation, draining, ventilation, etc. are moved by electric power, except two steam engines used for transportation set near the bottom of the shaft; in the Manda mine all engines and other pieces of machinery are moved by electric power, except the shaft pumps and the steam pumps at the shaft bottom, and the electric locomotive transportation along the underground level-ways which has been already described before, is especially remarkable.

Besides the above, in the Kachidachi, Miyanoharu and Nanaura mines, underground pumps are moved by electric power, except the shaft pumps and pumps set near the bottom of the shafts; on the surface, the central pumping station for boiler feeding, the water supplying station of Miike harbour, the wet dressing plant and all the workshops use electric motive power; and moreover in the Yotsuyama station six electric locomotives are running to transfer the reserved coals in the coal-storage to the Patent Miike skips; the latter also being moved by electric power.

The notes on the Calix boring machine and its practical results obtained are as follows.

The machine is one of the newest type of boring machines, made by the American New Calix Boring Machine Company. To bore soft rock the auger is used, while in case of driving hard rocks steel balls or grains are used instead of the auger. In such a way, a hole of 2,500 feet depth is easily driven down. The diameter of the initial iron drive pipe for the first 30 feet depth is 14″. Below that depth, the deeper the bore hole the smaller is the diameter of the pipes changing from 12″ to 5″. The diameter of the driving head attached with the auger or steel crown is 2″-2½″. This boring machine has been in use since 1907, and the results obtained are:—

1. The progress per month varies from 2.4 feet to 60 feet, and now is boring at the depth of 2,009 feet. The average rate of progress found by referring to the records of the actual working days is 6'8" per 24 hours.

2. The daily running expenses of this machine are greater than that of the diamond boring machine, for the reason that it requires much more power to move it, but as instead of diamonds steel grains are used, the total expense becomes smaller.

3. The practical operations and treatments of the machinery are very easy for the reason that in case of the meeting with fissures in the rocks, running drift, soft clayey rocks, underground cavities, watery strata and other impediments, gradually smaller pipes may be used to proceed with the driving; and up to the present drilling at the depth of 2,000 feet or more, no accident has reve occurred.

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## THE YOSHINOTANI COLLIERY.

The colliery is situated one and half miles west of Yamamoto, a station on the Karatsu line of the Kyūshū railway.

The coal seams occur in the Tertiary and there are eighteen of them; the lowest two of which that are workable, namely the upper or the Three-foot-seam and the lower or the Five-foot-seam, their vertical distance varying from 20 to 40 feet.

The coals of this region are known as the Karatsu coals and the average of their analysis is as follows :—

| Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Calories. |
|---|---|---|---|---|---|
| 1.52 | 42.36 | 44.45 | 11.67 | 1.32 | 7,260 |

There are three pairs of two slopes, one of the latter being the main slope used for transportation and a downcast, and the other used for communications, draining and as an upcast. For the purpose of sinking the Fourth shaft in the near future, a diamond boring is at present being driven.

The seams are worked by the long wall system. For underground pumping 15 electric three throw pumps are used. The ventilators in use are two Guibal fans and one Champion fan each discharging 90,000—100,000 cubic feet of foul air per minute. In the underground workings Davy and Clanny safety lamps only are used. Transportation on the slopes is carried on by hauling engines. The screening house is equipped with four movable screens and ten travelling bands. The coals are sized by the screens to large blocks, middle sized blocks and fine coal and the former two are subjected to hand-picking on the bands separately.

The transportation between the screening house and the station is facilitated by an endless rope of the under-rope but this will be replaced by the branch railway of the Karatsu line.

The distribution of the steam power actually in use is as follows:—

| | H.P. |
|---|---|
| Hauling | 1,059 |
| Endless rope | 240 |
| Ventilator | 195 |
| Boiler feeding | 193 |
| Workshop | 13 |
| Electrical power generated | 687 |
| Total | 2378 |

The number of labourers employed at the end of December 1908 was 3,160. The annual production of coal for the five years ending in 1908 was:—

| | long tons. |
|---|---|
| 1904 | 159,043 |
| 1905 | 167,330 |
| 1906 | 186,541 |
| 1907 | 221,024 |
| 1908 | 251,771 |

In the near future, both drinking water and feed water for the boilers will be pumped up to the plant from a river, two miles distant, with electric pumps forcing up 35 cubic feet of water per minute.

## THE ŌCHI COLLIERY.

This colliery is in the Karatsu region, and lies on a line drawn about one and a half miles west from Ōchi station on the Karatsu line of the Kyūshū railway and embraces the Ōchi and the Mutabe mine.

There are thirteen seams, the lowest two of which, named the Three-foot-seam and the Five-foot-seam are actually worked. The seams in the Tertiary and the strike being EW on the east and SN on the west and the dips 8°—15° S and W respectively.

The analyses of the coals are as follows:

| | Moisture. % | Volatile matter. % | Fixed carbon. % | Ash. % | Sulphur. % | Specific gravity. | Coloric power. |
|---|---|---|---|---|---|---|---|
| Ōchi-five-foot-seam | 3.12 | 38.04 | 58.80 | 5.72 | 0.82 | 1.290 | 7,480 |
| Mutabe-five foot-seam | 3.58 | 41.64 | 50.51 | 4.27 | 1.73 | 1.291 | 7,095 |
| Ōchi-three-foot-seam | 3.38 | 36.42 | 60.20 | 3.74 | 0.62 | 1.290 | 7,480 |
| Mutabe-three-foot-seam | 2.86 | 42.03 | 46.58 | 8.53 | 1.19 | 1.313 | 6,710 |

The mine openings actually in use are a rectangular downcast shaft of 13′×10′ section and 240 feet depth, a circular upcast shaft of 16 feet diameter and 270 feet depth and a slope in the Ōchi mine and two rectangular shafts in the Mutabe mine, one of the latter having 14′×10′ section and 230 feet depth is used for downcast and the other having 8′×7′ section and 270 feet depth for upcast. The length of the eastern and western main slopes in the Ōchi mine are 3,900 feet, and 3,000 feet respectively, while that in the Mutabe is 3,000 feet.

The coal is worked by the long wall system and besides cutting by manual labour three disk type coal cutters made by the Diamond Coal-Cutter Company, England, are used. They are the first coal-cutters actually used in Japan, according to the table of the result of their application, the amount of coal usually cut by manual labour in ten days is accomplished by the machine a single day, and one machine attended by four men cuts a face of eight feet length per shift of ten hours, the height and depth of the cut being five inches and four feet six inches respectively.

For pumping, electric three throw pumps, turbine pumps and special pumps are used, but within a short time in the future electric pumps will take the place of the special pumps, eight Lancashire and four Cornish boilers hitherto used being replaced by Babcock and Wilcox water-tube boilers while ventilating fans are set up and in action :—

| Mines. | Names. | Diameters. | Numbers. | Discharge of air in cubic feet per minute. |
|---|---|---|---|---|
| Ōchi. | Capell | 8′ | 1 | 100,000 actually in use. |
| Ōchi. | Champion | 8′ | 1 | 60,000 in reserve. |
| Mutabe | ,, | 8′ | 1 | 60,000 actually in use. |

On long level ways underground and in some parts overground endless ropes are in use. The lamps for the use of the miners are Cambrain Air-locked lamps, and officers are allowed to use Davy's lamps.

The actual motive power in use is as follows :—

| | H.P. |
|---|---|
| Transportation | 792 |
| Coal cutting machines | 60 |
| Draining | 180 |
| Ventilation | 159 |
| Dressing | 38 |
| Workshop | 29 |
| Electric lighting | 115 |
| Miscellaneous | 48 |
| Total | 1,421 |

The number of labourers at present in active service at the end of December, 1908 is 2,476.

The annual production of coal during the five years ending in 1908 was :—

| | long. tons. |
|---|---|
| 1904 | 122,573 |
| 1905 | 135,992 |
| 1906 | 146,781 |
| 1907 | 161,422 |
| 1908 | 161,468 |

But within a short time in the future, a shaft, capable of discharging 500 tons of coal a day will be newly sunk.

## THE TAKASHIMA COLLIERY.

The Takashima colliery is located on the island of Takashima, about 7 nautical miles south of the port of Nagasaki, branch mine of it situated on the island of Hashima, about 2 nautical miles south-west of the Takashima.

The coal seams are in Tertiary strata. There are sixteen of them, six of which named (1) the Upper-eight-foot-seam, (2) the Goma-five-foot-seam, (3) Banto-five-foot-seam, (4) the Eighteen-foot-seam, (5) the Three-foot-seam and (6) the Kakise-five-foot-seam, are workable. The vertical distance between (1) and (2) seam is about 360 feet, while the seams from (2) to (5) are lying closer within the depth of about 120 feet below (2) while the distance between (5) and (6) is about 85 feet. The general strike of the strata is NNE and the dip becomes gradually steeper from the north-eastern part of the Takashima mine to the south-western part of the Hashima mine, the former being 20°—25° NW and the latter 60°—70° NW.

The Takashima coals are said to be the best in Japan; their analyses are as follows:—

| Names of seams. | Moisture % | Volatile matter. % | Fixed carbon % | Ash. % | Specific gravity | Sulphur. |
|---|---|---|---|---|---|---|
| Upper-eight-foot-seam | 1.22 | 39.88 | 55.50 | 3.40 | 1.252 | 0.25 |
| Goma-five-foot-seam | 1.10 | 42.08 | 54.38 | 2.44 | 1.243 | 0.11 |
| Banto-five-foot-seam | 1.45 | 37.15 | 59.07 | 2.33 | 1.252 | 0.12 |
| Eighteen-foot seam | 1.10 | 36.95 | 59.94 | 2.01 | 1.253 | 0.10 |

There are four shafts actually in use; i.e. the First shaft of the 10′ × 14′ section, which is 550 feet in depth, and the Second shaft 10′ × 17′ section, 637 feet in depth, in the Takashima mine; while the remaining two are the Third and the Second shafts in the Hashima mine having sections similar to those of the Takashima shafts and being 651 feet and 531 feet in depth respectively. The length of the main slope in the Takashima mine is 2,040 feet and those of the second shaft and the third shaft in Hashima mine are respectively 1,400 feet and 1,700 feet. Moreover, on the Futagoshima, near the south-east coast of the Takashima, there are in the course of excavation the two main slopes from the surface, using one No. 5 water Leyner and one

Little wonder rock drill. As the Futagoshima was very small, in order to get sufficient space for a surface plant, high break-waters were first made around the island, and then the water within the break-waters was removed and the space reclaimed.

The method of working is the pillar and room system. As the roof of the coal seams is generally weak, the underground timbering is one of the tedious works of the colliery. With regard to draining, in the Takashima mine Special pumps only are used and in the Hashima mine three Worthington pumps having double steam cylinders of 34 inches diameter, a capacity of 80 cubic feet per minutes and 532 feet actual lift each, are set up for pumping purposes, the influx of mine water of the two mines being 15 and 70 cubic feet per minute respectively. Each shaft has one winding engine. As the dips of the seams are very steep, the underground transportation of tubs on the main slopes is carried on by underground hauling engines, while on the long level-way the work is done by endless rope. On the above ground transportation system, in Takashima, an endless rope air-line connecting the shafts and the Takashima pier, is employed. The transportation of coals from the two islands to the Nagasaki port is carried on by means of 200 long ton junks, the coals in tubs on the piers being directly loaded into the junks. This colliery is one of the fiery mines in Japan. Accordingly, for the sake of getting better ventilation, in the Takashima mine two Guibal ventilators of 24 feet and 18 feet diameter are set, the former of which is actually in use discharging 70,000 cubic feet of foul air per minute, and in both shafts of the Hashima mine ventilators of the same type of 24 feet diameter each are set splitting each shaft into two compartments, the total discharge of foul air in the latter mine being 12,000 cubic feet per minute. As miner's lamps Thomas William safety-lamps and as underground officer's lamps Davy's safety-lamps are used.

The motive powers in use are as follows :—

| | | | |
|---|---|---|---|
| Hauling | 322 H.P. | Draining | 2,396 H.P. |
| Winding | 1,062 ,, | Endless | 50 ,, |
| Ventilation | 207 ,, | Electric lighting | 175 ,, |
| Workshop | 64 ,, | Miscellaneous | 862 ,, |

Total 5,138 horse-power.

The number of labourers employed at the end of December, 1908 was 2,693. The annual production of coal for five years ending in 1908 was:

| | long tons. |
|---|---|
| 1904 | 229,592 |
| 1905 | 204,026 |
| 1906 | 146,172 |
| 1907 | 182,357 |
| 1908 | 184,816 |

In order to work five seams, lying 360 feet below the Upper-eight-feet-seam worked formerly from the Nakanoshima it was designed, to excavate two parallel main slopes (120 feet apart) of $10' \times 8'$ section, 25° inclination, 1,200 feet vertical height and 2,700 feet inclined distance, in the Futagoshima; to use two Weise-Monski turbine pumps, each of 30 cubic feet per minute capacity, in each pumping station made by holing through the slopes at the intervals of 200 feet inclined distance (the pumping during singking of individual slope being carried on by three throw electric pumps); to drive two parallel cross cuts, each of 3,240 feet in length, from the slope bottoms to the Nakanoshima lower field; and thus to secure 1,000 tons of coal a day. As result of this plan up to the end of May, 1909, the first slope had been excavated to the extent of 740 feet and the second 730 feet.

The motive power used in pumping and transportation in the Hashima mine will be altered within a short time in the future from steam to electricity using a generator of 300 kilowatts and 550 volts and by this alteration all steam pumps in the Hashima mine will be replaced by Weise-Monski turbine pumps, each having a capacity of discharging 35 cubic feet of water per minute.

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## THE NIITSU OIL-FIELD.

The Niitsu oil-field lies on a hilly region about 100 feet high above the sea at the south-east of the town of Niitsu, Echigo. The region has long been known to be oil-bearing and for a long time was worked by the hand dug wells.

The exploration was commenced at Kumazawa district by the well of the improved Chinese method which struck an oil spring in 1893. Since that date, other wells had been bored around the original site, and further interest had been attracted to the place by the appearance of a small flow well; but until a few years ago, the oil industry of this oil-field was almost entirely confined to the district of Kumazawa and Koguchi.

The workings became somewhat active from the beginning of 1904. Since then the oil-field has been rapidly stretched to the adjoining districts toward the south. At present, the oil-field extends from the town of Niitsu in the north to the south region of Yashiroda station in the south and is about 7 miles in length. Indeed, so a remarkable progress has since then been made as to the amount of oil that more than half of our total production is extracted from the Niitsu oil-field.

The Tertiary formation of oil-field belongs to the upper and middle series. The middle series, which consists of sandy shale interspaced with sandstone, occupies the most part of the hilly region, and the upper series of sand, shale and gravel are seen only in the west side of the region. The geological structure is complicated by numerous small folding, but it seems that three defined oil-belts exist in the oil-field.

The principal oil-belt is that which extends from Kumazawa in the north, through the districts of Koguchi, Asahi and Jūgasawa and along the north border of augite andesite mountains, to the districts of Ashiaraiba, Amagasawa and Kamakurashiuden in the sonth-west. Two other oil-belts lie on both its sides. The oil-belt on the east stretches from the Niitsu town to Mayedani district in a direction of north-west to south-east. Another oil-belt on the west comprises the districts of Higashijima, Kodani, Shiodani and Kanatsu.

The oil in the field is contained in the coarse sandstone interlaid among the layers of sandy-shale of the middle series. This sandstone layer is 4 feet to 15 feet in width and is 540 feet to 780 feet in depth. Two deep trial borings were carried on at Kumazawa and Kodani districts by the Nippon oil company; but both were finished unfortunately without success. However, there are almost sure to be other oil bearing strata as there are no signs in the lowest beds to lead one to conclude that the bottom of the series has been reached; and so further investigation must be conducted to discover the deep oil-bearing horizons of the field.

The quality of oil is the most inferior among all those of our oil-fields and is deficient in kerosene. The Baume degree is 13° to 20°. Especially, the quality of the oil become much inferior in the districts from Jūgasawa toward the south where eruptive rock occurs in the vicinity; and oil from these districts are thick black oil resembling tar in consistency and appearance. The following table exhibits the analyses of oil from the Koguchi and Kumazawa districts.

| | Oil from Koguchi. | Oil from Kumazawa. |
|---|---|---|
| Light oil | 35% | 32% |
| Heavy oil | 40% | 54% |
| Pitch | 16% | 9% |
| Loss | 9% | 5% |

The workings are made mostly by American drilling, but in several places, the wells of the improved Chinese boring are still now used together, on account of the oil-bearing horizon being shallow in depth. In the Amagasawa and Kamakurashinden districts, where the oil is so heavy to be difficult to be drawn up from the drilling wells, the workings are made only by the wells made by manual labour.

The chief companies exploiting oil at present are the Hōden, the Nippon, the Chyūō and the Nakano. The yearly output from the oil-field since 1903 is follows:—

| Year. | Annual output of oil from Niitsu. (in barrels.) |
|---|---|
| 1903 | 356,296 |
| 1904 | 603,065 |
| 1905 | 720,484 |
| 1906 | 918,293 |
| 1907 | 1,089,437 |
| 1908 | 950,329 |

The decrease of the output last year is conjectured mostly to be a result of the fact that the main attention of the Nippon and the Hōden oil companies was turned toward the development of the Miyagawa oil-field during that year.

The oil-wells, which had yielded oil to the amount of more than 100 barrels a day for a time when they were struck, are numerous in several districts of the oil-field.

The predominant districts at present are Asahi, Koguchi, Kanatsu, Kodani and Shiodani, the centre of exploitation being in Asahi. Besides, the oil-field is not expanding in a plain beyond the river Nodai toward the north.

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## THE HIGASHIYAMA OIL-FIELD.

Higashiyama oil-field lies on the so-called Higashiyama mountain range rising from 400 feet to 550 feet above the sea level and is situated nearly seven miles east from the city of Nagaoka in Echigo province. The mountain range runs in a direction from north to south and is fringed by the Kariyama river on the north and by the Shinano river on the south.

The two district anticlines exist in the oil-field. One of them coincides approximately with an axis of the mountain range and extends along the whole length of the same about 17 miles. The other anticline runs parallel to the former on the east side and extends from the town of Tochio toward the south along the Nishitani river. The former anticline is the main productive oil-belt in the oil-field. Of the latter, there is known at present nothing more than that two trial wells were once bored in this anticline by the Ōhira and the Zaō oil companies which were not successful; but the value of the entire oil belt must not be decided by the result of a few wells.

The Tertiary formation composing the oil-field consists of the strata of the upper, middle and lower series. The upper series is divided into the upper part which consists of clay, sand, gravel and andesite boulders, chiefly sand layers predominating and the lower part which consists of sandstone and clay-shale with sand and pebbles. The middle series consists of sandy shale with argillaceous sandstone and tuff breccia. The lower series consists of shale in which occur intercalations of sandstone, tufaceous sandstone and tuff breccia. Oil is generated from the sandstone intercalated in the shale of the lower series.

As shown in the figure, rocks of the lower series are exposed along the anticlines, and those of the middle series are widely exposed on both wings of the anticlines covering the former. Rocks of the upper series are only seen along the west foot of the mountain range and in the southern part of the oil-field where they are exposed to a large extent.

The Higashiyama Oil-Field Proper :—The well-known districts, which are commonly called the Higashiyama oil-fields, contains Tsubakizawa, Katsurazawa, Katsubozawa, Urase and Hire, which form collectively a continuous oil-belt along the main anticlinal axis.

The total area yielding oil measures nearly 650 acres, being about 4,000 yards in length and 300 yards to 900 yards in width.

The anticlinal strata in these regions have a gentle slope toward both wings and there are known four oil horizons. The upper three oil strata were struck several years ago, and these take place comparatively close to each other, lying between about 600 feet and 900 feet below the surface, but the fourth oil stratum is separated from the former by a considerable thickness of strata. In the year 1907, it was struck by No. 59 well at Hire of the Hōden Oil Company. The well is 1,938 feet in depth, and it is recorded that there was the daily output of oil to the extent of about 100 barrels at the time when it was struck.

The main plots which are now yielding oil are in the possession of the Hōden and the Nippon Oil Companies.

The oil-wells are now chiefly bored by American rope drilling method. Oil from the upper three strata being mostly exhausted ; but in the Katsubozawa district, there are now a large number of the old style wells which are conducted by many small associations. The depths of these wells are from 540 feet to 660 feet, and the daily output from a well of this kind is no more than 3 barrels.

In the time of the evolution of the Higashiyama oil field, (1894—1896) there were many productive drilled wells which yielded more than 500 barrels a day, but after that time, the daily output per well has greatly fallen off, and at present the well which yields 10 barrels a day is good one, the average daily output per well being 2.2 barrels. Nevertheless, an interesting point of this oil-field is the long continuation of the output from the oil-wells, as may be seen in the case of the No. 4 well at Hire of the Hōden Oil Co., which is still at present yielding 14 barrels a day continuing its output during the ten years since it was struck.

The statistics of the annual total output of oils from these districts since 1903 is as follows:—

| Year. | Annual output of oil from Higashiyama oil-field proper. |
|---|---|
| 1903 | 382,217 barrels. |
| 1904 | 371,321 „ |
| 1905 | 309,020 „ |
| 1906 | 346,025 „ |
| 1907 | 388,049 „ |
| 1908 | 234,477 „ |

The list shows generally the diminution of the production year after year, although in 1906 and 1907 there was a increase of the production, which depended upon the expansion of the oil-field and upon the repair and working of many abandoned oil-wells by the rise of the price of oil at these times. But as the fourth oil-bearing stratum at present remains almost everywhere not yet bored; if it be bored, or if an extended exploration be conducted, the annual production will undoubtedly be increased in the future.

The crude petroleum of the Hōden Oil Company together with that of the Nippon Oil Company, oils from the four strata being mixed, are transported to the Nagaoka Refinery by the pipe line and are refined by the former; while instead of this, in the Naoyetsu district the output belonging to the former is refined by the latter, together with oil from the Kubiki oil-field of both companies. Such arrangements have resulted from the relation between the oil-fields and the refineries of both companies aforesaid.

The Baume degrees of the crude petroleum from every oil-stratum are as follows:—

| | | Baume degree. |
|---|---|---|
| Oil from 1st stratum at | Tsubakizawa | 25° |
| ,, 2nd ,, ,, | Katsubozawa | 20°-30° |
| ,, 3rd ,, ,, | Hire and Uraze | 29°-32° |
| ,, 4th ,, ,, | Hire | 38° |

The list shows that the quality of the oil becomes so much the better as the oil-bearing stratum becomes the deeper.

The percentage of the refined petroleum products of the crude petroleum, according to the report from the Hōden Oil Company is as follows :—

| | |
|---|---|
| Benzine | 7% |
| Kerosene | 43% |
| Light Oil | 4%-5% |
| Heavy Oil | 31%-32% |
| Pitch | 7% |
| Loss | 5%-6% |

The Takezawa District :—In the Takezawa district lying on the south part of the Higashiyama mountain range, there has been an oil-yielding region since many years ago. The oil-wells are 300 feet to 360 feet in depth. The quality of the oil is better than that of the Higashiyama oil-field proper, but the output is very small. Though these wells lie on the same oil-belt, the oil-bearing sandstone being very thin and the inclination of the strata being very steep in this district, much future development is quite uncertain.

The Araya District :—Also, in the Araya district situated in the south about 1.5 miles from the Takezawa district, a trial boring was undertaken in the last year but it did not succeed though it had proceeded to the depth of more than 1,500 feet.

# THE NISHIYAMA OIL-FIELD.

The mountainous region rising on the west of the city of Nagaoka and on the opposite side of the Higashiyama mountain range is called Nishiyama.

The Nishiyama region is topographically divided into two parallel mountain ranges by a longitudinal valley, in which the two rivers Betsuyama and Torizaki run south-westward and north-eastward respectively. The mountain range lying on the west is called the coast mountain range and other lying on the east is called the Oginojō mountain range.

The Tertiary formation of this region is composed of the upper series consisting of soft sandstone, soft shale and gravel, the middle series consisting of sandy-shale with calcareous fossil layers, and the lower series consisting of alternate layers of shale and sandstone in the upper part and shale in the lower part.

The strata of the lower series are exposed lengthwise along the axes of the two mountain ranges; those of the middle series occur on both sides of the former outcrops; and those of the upper series are only seen in the north part of the longitudinal valley, and in the east foot of the Oginojō mountain range where it occupies an extensive area.

There exist the five oil-bearing anticlines in the region, known as the oil-fields of Amaze, Miyazawa, Kamada-Nagamine, Myōhōji and Nanokaichi. The upper three oil-fields lie in the coast mountain range, and the lower two in the Oginojō mountain range. Those which are commonly known as the Nishiyama oil-field are the two rich oil-fields of Miyagawa and Kamada-Nagamine.

The Miyagawa Oil Field :—The Miyagawa oil-field lies on the centre of the coast mountain range about 130 feet above sea level and is located about 5 miles north-east from the town of Kashiwazaki from whence all material are carried.

In 1894 the oil-field was explored for the first time by the Nippon Oil Company; and for many years after that time, much attention had not been attracted to that field, because the oil-bearing bed was comparatively deep and the output was generally little, except that No. 15 oil-well of that company yielded in 1902 at one time oil to the amount of 80 barrels per day in a depth of a little more than 1000 feet.

Therefore the total daily production in the oil-field was not more than 100 barrels until the end of the years before last.

According to the recent development of the arts especially of the operation of the drilling, the Nippon Oil Co. tried at the end of 1906 to bore out two old wells. As the result, in February 18th 1908, the well No. 14 met with a strong flow of petroleum at a depth of 1,986 feet, which is reported to have been 140 barrels per day for a time. Secondly in March 27th of the same year the work in the well No. 26 resulted at 2,058 feet in a big fountain or gushing well. Since then many old wells have been bored down deeply or new deep drillings have been undertaken by this company and also by the Hōden Oil Company. All of them having been crowned with success a remarkable progress has recently been made. The most recent productive oil well is No. 4 of the Nippon Oil Company which struck on June 23rd 1909 huge spouter of oil to the amount of about 400 barrels per day.

Under such circumstances the progress has been remarkable, the total daily output from the oil-field which was no more than 80 barrels in September 1906 had rapidly advanced to about 380 barrels in May 1907, and in October 1908 to the remarkable amount of 1,200 barrels which had not ever been recorded in the Nishiyama oil fields.

The plots of the oil-field belong to the possession of two oil companies, the Nippon and the Hōden. The daily output of oils and the number of the wells of the two companies in July 20th 1909 are as follows :—

| Name of Company. | Number of productive oil-wells. | | Number of oil-wells under repair. | Number of oil-wells being dug. | Daily output in barrels. |
|---|---|---|---|---|---|
| | Shallow bed. | Deep bed | | | |
| Nippon | 4 | 21 | 0 | 20 | 505 |
| Hōden | 10 | 10 | 6 | 9 | 190 |
| Total | 14 | 31 | 6 | 29 | 695 |

The area under active exploitation measures approximately 150 acres and extends from the Miyagawa district to the Ushirodani district in a direction south-west to north-east along the anticlinal axis. A more extensive expansion of the oil-field would certainly be expected by several wells, which are now at work in both extremities of the anticlinal axis. For each wing of the axis the dip is in the east 20° to 30° and in west is 30° to 40°.

The Baume degree of crude oil from the 2nd oil-bearing bed which lies at a depth between 1,860 and 2,100 feet is 43° to 45°, and this oil contains paraffin ; while that from the first oil-bearing stratum which lies at about 1,320 feet below ground is 32° to 35° is inferior in quality compared with the former. The percentage of the refined products from the deep stratum to the crude oil is as follows :—

| | Per cent. |
|---|---|
| Benzine | 14.00 |
| Kerosene | 58.17 |
| Light oil | 14.67 |
| Heavy oil | 10.40 |

The following list shows the annual output from this oil-field since 1906.

| | Barrels. |
|---|---|
| 1906 | 15,216 |
| 1907 | 40,854 |
| 1908 | 176,550 |

The Kamada-Nagamine Oil-Field :—The Kamada-Nagamine oil-field, which comprises the three districts of Nagamine, Kamada and Imo, lies on the east foot of the coast mountain range at a distance of about half a mile from the Miyagawa oil-field.

The field had been first explored in 1898 and within a few years had remarkably developed in the districts of Kamada and Nagamine ; whilst in the adjoining district of Imo, attention had not been particularly attracted by the knowledge of the unsuccessful results of many wells bored in that district.

The year 1901 was a most flourishing time of the Kamada and Nagamine districts, but during the next year, these districts began to show evidence of a slow decline, the output of oil being decreased by degrees ; and perhaps the declination would have been still more continued, if the boring of a deep well accomplished the Imo district in 1905 by the International Oil Co. had not been crowned with success.

After this success, the oil-field was instantly expanded toward the Imo district and marked activity is now being made northward, the output of oil having been increased again as stated in the attached list of the annual production.

| Year. | Annual production of oil from Kamada-Nagamine (in barrels.) |
|---|---|
| 1903 | 321,680 |
| 1904 | 307,140 |
| 1905 | 307,313 |
| 1906 | 318,810 |
| 1907 | 367,679 |
| 1908 | 542,741 |

The area under active exploitation measures about 300 acres.

At present, there are known to be the three oil-bearing horizons in the oil-fields; the upper two strata are those worked in the districts of Kamada and Nagamine at the beginning and the third stratum is that discovered by the International Oil Co. at Imo. The depths and Baume degree of oils from the three strata are as follows:—

| Oil bearing stratum. | Depth in feet. | Baume degree. |
|---|---|---|
| 1st | 600–780 | 23°–27° |
| 2nd | 900–960 | 30°–36° |
| 3rd | >1,500 | >35° |

Old wells, from which the oil of the first and second strata had once been exhausted, are now mostly being bored down for the third stratum or even deeper strata.

The oil companies which are now at work in the oil-fields are the Nippon and the Hōden, the concessions of the International Oil Company having been sold to the Nippon Oil Co. The number of wells and the daily output of oils from the oil-field in July of this year are as follows:—

| Name of Company. | Number of productive oil-wells | | Number of oil-wells under repair | Number of wells being dug. | Daily output in barrels. |
|---|---|---|---|---|---|
| | To 1st and 2nd stratum. | To 3rd stratum. | | | |
| Nippon | 117 | 24 | 0 | 15 | 580 |
| Hōden | 89 | 7 | 13 | 16 | 334 |
| Total | 206 | 31 | 13 | 31 | 914 |

It is worthy of note in this oil-field, that besides oil-yielding wells there are many natural gas wells productive at the depth of from 1,560 feet to 2,000 feet. The gas wells which emitted enormous quantities during this year, are the well No. 55 at Imo and the well No. 33 at Kamada of the Nippon Oil Co. It is recorded that the former has produced gas to the amount of about 4,500,000 cubic feet a day together with oil to the amount of about 60 barrels and that in the latter the amount of gas was about 2,000,000 cubic feet a day at the time when each was struck. The gas wells in July of 1909 were 15 in number, 10 existing at Nagamine, 4 at Kamada and 1 at Imo. The natural gas, now being accumulated and conserved, is used as fuel for the boring in the Miyagawa and the Kamada-Nagamine oil-fields and also as fuel for the refinery of Kashiwazaki. Its total quantity used a day corresponds to about 240 barrels of heavy oil.

The Amaze Oil-Field:—The Amaze oil-field lies close to the shore of Sea of Japan about 7 miles north from the Miyagawa oil field and comprises the three districts of Amaze, Katsumi and Ishizi.

The Amaze district is historically famous in the development of our oil industry as being the first region in which rope boring was successful.

The most flourishing time of this oil-field was in the year 1894 and the total output of that year amounted to more than 34,000 barrels. But this district has since come to assume a steady decline year after year, the sources of oil having been drained. However recently the output has been increased to a certain extent by the development of the new districts of Katsumi and Ishiji as exhibited in the attached table.

| Year. | Annual output of oil from Amaze in the barrels. |
|---|---|
| 1904 | 8,289 |
| 1905 | 8,608 |
| 1906 | 8,970 |
| 1907 | 14,175 |
| 1908 | 19,138 |

In the oil-field, oils occur in sandstone and tufaceous sandstone interlaid among lower shale, or sometimes a huge fountain springs from the shale itself. There are numerous oil-bearing horizons in the oil-field and so the depths of the oil-wells are very variable; a shallow well is only 200 feet in depth while a deep well often exceeds 1,800 feet.

The quality of oil is superior in all oils from our oil-fields, the percentage of kerosene to the crude oil being 84 per cent. and the Baume degrees of the crude oil ranging from 38°—42°.

The Myōhōji Oil-Field:—The Myōhōji oil-field extends along the whole length of the Oginojō mountain range lying a little west from its summit. So the length of the oil-field is about 10 miles, but the width is no more than 656 feet on account of the acute inclination of the anticlinal strata.

This oil-field has been much exploited from ancient times by the wells dug by manual labour, and until about the year 1887 it was one of the important oil-fiedls in Echigo, which was known by the name of Sakata, Myōhōji and Kusōdzu. But recently the petroleum seepages were drained, and many of the old wells excavated by manual labour had come to be abandoned. The quality of oil was generally good and the Baume degree was from 35° to 38°.

The Nanokaichi Oil-Field:—The Nanokaichi oil-field is situated on the east foot of the Oginojō mountain range, and the districts under exploitation are the Nanokaichi and the Ushirodani. The oil of this field occurs in the shale of the middle series and the working is made by the wells of improved Chinese boring.

Two oil-bearing horizons are known, the first horizon lying at the depth of from 180 feet to 300 feet and the second horizon at the depth of about 480 feet. As the output from the first stratum is very small, many oil-wells are generally struck in the second stratum; the oil-well which yields 10 barrels per day is the best one in this district. The oil belongs to the class of deep brown heavy oils and the Baume degree is about 16°.

The concessions belong to the Nippon Oil Company and private individuals. As the anticlinal strata in the oil-fields are gentle in their inclination, much development may be expected in the future.

## THE KUBIKI OIL-FIELD.

The Kubiki Oil-Field is a general name for many oil-fields or Hara, Iwagami, Gendōji, Kukuno and Matsunoyama which lie scatteringly among the southern parts of Higashi-Kubiki and Naka-Kubiki counties in Echigo.

The chief oil-fields, which are now yielding oil, are the Hara, the Iwagami and the Gendōji, and these are situated in the valleys at the distance of from 10 miles to 12 miles south-east from the town of Takata; while the other two oil-fields belong to the oil districts of old time and are still left comparatively neglected.

In geological formation, the oil-fields of Hara, Iwagami and Gendōji are composed chiefly of the shales of the lower Tertiary series, in which are interposed thin layers of sandstone and thick strata of greenish white tuff. The geological structure in the oil-fields is extremely complicated with many foldings and dislocations.

Oil is obtained at the depths of from 600 feet to 900 feet from the strata of greenish white tuff. The quality of the oil is very good and the Baume degree is 40° to 45° in the Hara and the Iwagami, 38° to 43° in the Gendōji. The average percentage of the refined petroleum products to the mixed crude petroleum is as follows:—

| | Per cent. |
|---|---|
| Benzine | 4 |
| Kerosene | 64 |
| Light oil | 16 |
| Heavy oil | 15 |

Generally, the output of oil from the wells of these fields is very variable and does not continue to yield so long as the wells in other oil-fields. This fact is conjectured to be caused by the character of the oil-bearing strata which are very compact in some parts or very loose in others.

Under such conditions, these oil-fields did not become more developed than had been expected. The attached table states the yearly output of oil from these districts.

| Year. | Annual output of oil from Kubiki (in barrels.) |
|---|---|
| 1903 | 102,575 |
| 1904 | 77,253 |
| 1605 | 111,311 |
| 1906 | 88,378 |
| 1907 | 72,242 |
| 1908 | 68,841 |

In the prosperous time of these oil-fields, there were many oil-companies such as the Nippon, the Nagaoka, the Tomoe, the Hōden and the International Oil Companies, but at present two oil compaies, the Nippon and the Hōden only remain.

The Hara Oil-Field:—The Hara oil-field lies on the four parallel anticlines occurring near each other in the upper valley of the Iida river and extends from the Kitano district on the west to the Hara and the Tanahiro districts on the east.

The field was first explored in the Kitano district by the Nagaoka Oil Company in 1900, and it is recorded that the first successful oil-well by that company had yielded oil to the amount of about 50 barrels a day at the beginning. Then the oil-field was extended toward Hara and Tanahiro, and the year 1903 proved to be most successful.

Three horizons of oil-bearing tuffs are known and in this oil-field, oil is obtained from the two upper horizons.

At present, the centre of exploitation is in Hara and Tanahiro; the number of productive oil-wells is about 100 and the total daily output of oil is not more than 100 barrels.

The Iwagami Oil-Field:—The Iwagami oil-field lies on the anticlinal axis which extends from Iwagami district to the districts of Tajima and Shimobirugo. The oil-field commenced to attract attention since a well bored by the International oil-company had succeeded at Iwagami in 1903. After that time, the oil-wells were rapidly increased in the neighbourhood and the area is now expanding toward the south-west to Tajima and Shimobirugo.

The oil-well, which most recently produced a huge amount of oil, is No. 93 which struck the steam at a depth of about 840 feet in November 1907; and it is recorded to have given more than 250 barrels a day for a time. The oil-bearing stratum is the tuff of third horizon.

The Gendōji Oil-Field :—The Gendōji oil-field comprises the five districts of Fukuzawa, Gendōji, Tatsuno, Tsutsukata and Kurizawa, which lie along the anticlinal axis.

It flourished during the years from 1877 to 1887. The yearly output at that time was more than 10,000 barrels, but it decreased year after year until it become diminished to about 3,400 barrels in 1907.

These oil-wells belong to the class of wells dug by manual labour which have a depth of from 360 to 800 feet. Though several American rope-drillings were tried from time to time, the output of oil being so very little that it did not compensate for the expense, and consequently they were almost all abandoned.

As in the oil-fields oil-bearing tuffs are very thin and occur close to each, so it seems probable that the hand dug wells may perhaps be able to obtain such oil rather more easily than the American rope-drillings.

# SUPPLEMENT.

## THE CUSTOM SMELTERS.

Custom smelters are still in a primitive stage in Japan, owing to the high cost in freight and to such old habits that people were not suffered to smelt ores at place distant from the mine. Recently large smelting plants at mines such as Hitachi, Ikuno, Kosaka, etc., however, have begun to smelt ores from other mines. The Inland sea is full of many isolated islands which afford free use of the grounds for these works and are free from the fear of injury from the fumes, the danger of which is so clamorous a subject for delate in Japan as well as in America. Moreover, since the smelters are thus situated upon islands in the Inland sea at no great distance from the lands in any direction, they enjoy the benefit of cheap freights by means of Japanese junks, both in getting fuel from coal lands in the western direction and to bring their products to market in the ports towards the east. Also, in the adjacent lands there are many small mines, especially in the Sada peninsula, on the bank of the river Yoshino (Awa) and the region of Sonyō, as well as in Bungo and Kii. Thus custom smelters were erected in or along the sea, fed with the pyrite ores from those districts; pyrites of the Kune mine, quartzose ores from the Ikuno mine and Kinkwaseki mine (Formosa) are also treated in the smeltsrs, names of which can be seen from the following table:—

| Names. | Provinces. | Capital invested. | Date of erection. | Ore treated per month | Copper produced per month. | Total H.P. of engines. | Number of labourers. | Furnaces. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Long tons | Long tons. | H P. | | | |
| Sashima | Iyo | £75,200 | 1907 | 2,407 | 40 | 80 | 250 | One 8′ × 3.3′ Three 3.8′ dia. | A surphuric acid manufacturing plant is in process of erection. |
| Mekkō | Iyo | £ 8,200 | 1897 | 333 | 16 | 37 | 22 | One 4′ dia. | |
| Hibi | Bizen | £ 9,200 | 1987 | 1,111 | 44 | 50 | 63 | One 3.3′ × 6′ | |
| Ogushi | „ | £51,300 | 1900 | 1,500 | 55 | 400 | 114 | One 3.2′ × 6′ One 3.5′ dia. | This work is mainly for fertilizers and sulphuric acid. |
| Midzushima | „ | £10,300 | 1903 | 903 | 30 | 45 | 105 | One 3.3′ × 8′ One 3.8′ dia. | |

The methods of smelting adopted by these works are partial pyrite-smelting, the roasted ore being made in the same plant or supplied from other sulphuric acid manufacturers. The blister copper produced contains some noble metals and is shipped to the refinery-works at Osaka. They have all their own coke-making plants, and those in the islands suffer from scarcity of water, hence in Sashima Campell's gas-engines of Halifax & Co. are used with good results. There are two smelters going to be erected, besides the above mentioned ones.

There are twelve refineries at Osaka, among which we shall describe here about the Osaka Refinery which is possessed by the Mitsubishi firm. It was erected by the Bureau of the Imperial Estate in 1891 and came into the possession of the present owner in 1896.

At this refinery blister coppers from the mines belonging to the same firm and others are treated. These coppers are first refined to 97—99% in English reverberatories and then erectro-refined by the multiple system, there being 520 vats for this purpose; the capacity of which is about 1,000 long tons a month. Some of the electro-copper is again melted in a reverberatory into ingots and exported to China; some electro-copper goes to England, etc. This copper contains 99.96% copper. The anode slime produced in the electro-refining is melted with lead in a reverberatory and then subjected to cupellation according to the English practice. The parting of the bullion is effected by electrolysis, there being seven vats for this purpose. The tenor of the gold and silver is 99.6 % and 99.9 % respectively; the former is sent to the Imperial Mint at Osaka, the latter to China as well as to the mint, copper vitriol 99.5% in purity is also produced there from blister-copper. It is produced from granulated copper (97—99% copper) by the Oker process. The plant manufactures also electric copper plates by a revolving cathode system, which is to be enlarged at an early date. We find there one blast furnace, twelve reverberatories, five hundred and twenty vats for electric copper refining, seven vats for the parting of gold and silver, two vasts for manufacture of copper vitriol. The chief motive power is one 450 H.P. steam engine, two 250 H.P. engines, one 300 k.w. dynamo and two 200 k.w. dynamos, etc. The persons employed at the end of 1908 were 176, and the productions of six years ending 1909 are as follows:—

| Year. | Gold. troy oz. | Silver. troy oz. | Electro-copper. long tons. | Copper-vitriol. long tons. |
|---|---|---|---|---|
| 1904 | 20,698 | 599,255 | 3,794 | 671 |
| 1905 | 19,391 | 540,841 | 4,037 | 797 |
| 1906 | 18,130 | 498,543 | 4,131 | 776 |
| 1907 | 18,600 | 613,581 | 5,862 | 851 |
| 1908 | 26,553 | 549,950 | 4,827 | 961 |
| 1909 | 60,652 | 609,435 | 6,365 | 965 |

電話新橋五〇一三番

發行所　東京市京橋區三十間堀三丁目三番地　英文通信社

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印刷人　東京市銀座四丁目一番地　岸山芳太郎

發行人　東京市京橋區三十間堀三丁目三番地　望月小太郎

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