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HOW JAPAN'S METAL MINING INDUSTRIES MODERNIZED

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CONTENTS

I. METAL MINES AT THE END OF THE TOKUGAWA PERIOD (1600-1868) AND THE BEGINNINGS OF MODERNIZATION

Generally speaking, after around 1830 Japan's mines, especially those that produced non-ferrous metals, were in a state of stagnation. Their poor performance was caused by a complex interaction of factors which had come to inhibit growth and which continued in spite of serious efforts by the central government and the governments of the various han [feudal domains] to stimulate production. The increased production at the Innai silver mines in Akita han in the northwestern part of Honshu (Japan's main island) was an exception (see Table 1).[1]

But this "success" at the Innai mines, which produced an average of about 4,500 kilograms of silver per year during the 11-year period 1833-1843[2] (an especially difficult period for Japan, when the

TABLE 1. Production from the Innai Silver Mines (1817-1875) (Unit: kan = 3.75 kg)

Year	Volume of metal produced (kan)	Year	Volume of metal produced (kan)	Year	Volume of metal produced (kan)
Aug. 1817		1836	1,091.2379	1856	540.0603
to Dec.		1837	1,167.3010	1857	804.6583
1818	91.1397	1838	1,438.1500	1858	523.5932
1819	101.1072	1839	1,149.7961	1859	587.5555
1820	73.2372	1840	1,278.5208	1860	784.5153
1821	94.1185	1841	1,027.5598	1861	541.1771
1822	92.6587	1842	1,151.9257	1862	700.3950
1823	236.5255	1843	1,068.2577	1863	311.4382
1824	387.7956	1844	766.6110	1864	255.7600
1825	309.5612	1845	503.5400	1865	294.3300
1826	311.3615	1846	573.3100	1866	324.7087
1827	408.8315	1847	756.6790	1867	375.0473
1828	537.4974	1848	532.0400	1868	319.3256
1829	529.5456	1849	480.2540	1869	314.9390
1830	467.8772	1850	445.1908	1870	390.0449
1831	381.8926	1851	357.0198	1871	418.6459
1832	388.6008	1852	447.4472	1872	381.7971
1833	1,178.3907	1853	418.9096	1873	370.0301
1834	1,399.4041	1854	384.6432	1874	347.3326
1835	1,345.4246	1855	706.3718	1875	305.9176

Source: Kōbushō Innai Hashutsu Shichō, comp., Innai kōzan ryakki, 1876.

country suffered from widespread famine), was not the result of any particular technological innovations in mining or refining but was simply due to good luck in finding rich veins of ore.[3]

In the case of copper mining, production in the year 1685 had reached approximately 5,200 tonnes, of which some 4,800 tonnes were exported to Holland and China. Afterwards, yearly production of copper gradually decreased, falling to only about 1,000 tonnes in 1860.

One reason for this stagnation was the government's policy of monopolizing copper purchases at low prices. But a still more basic reason lay in the antiquated methods of mine management and operation which had been in continued use since at least as early as the establishment of the Tokugawa governmental system at the beginning of the seventeenth century. The Tokugawa system was one of feudal domains (han) subject to a certain degree of central control from Edo (present-day Tokyo), with members of the Tokugawa family in the positions of highest authority.

Under the prevailing methods of management, the mines were owned by the central government, known as the bakufu, or by local han governments. However, among the government employees there was by no means an accurate or adequate knowledge of the technology or basic concepts necessary for modern development and management of mines. Governments limited their activities to such matters as ordering test excavations, loaning funds to subcontracted managers, selling rice from government warehouses to mine workers at reduced prices, or providing lamp oil and water. They also purchased the ore produced.

The actual organization of all work directly connected with production, such as ore extraction, concentration and refining, was delegated through a sort of subcontract or agent system to various categories of persons called yamashi (nearly independent entrepreneurs and mine operators who worked in almost the same way as if they had in fact owned the mines), kanako (middlemen seeking individual profits, who were subordinate to the aforementioned operators), or, in some regions,

kaiishi (subcontractors in charge of refining).

These mine organizers paid money to the central or local governments in order to obtain their positions. The amounts paid were sometimes rather large, often representing the highest bid from among a number of applicants. The subcontractors, in turn, controlled groups of workers with specialized mining skills.

The traditional mine organizers (yamashi, etc.), who monopolized all direct production activities, had no scientific management concepts based on production targets or set plans. Rather, they typically had a bonanza-seeking mentality, carrying out excavations in an arbitrary way, intent on immediate profits from rich, though quickly exhaustible, ore shoots.[4]

This type of behaviour was no doubt due in large part to the limitations of the refining technology of the time, which excluded the refining of low-quality ore. In any case, the unsystematic digging of tunnels in the pursuit of quick bonanza yields brought many problems which held down overall production. These may be summarized as follows:

1. The mine managers generally had scarce operating capital and, in an attempt to minimize the costs of excavating in the search for rich ore shoots, they tried to avoid digging tunnels through areas of hard rock, preferring instead to dig around such formations. The tunnels not only had a great many twists and turns, but were extremely narrow, often no larger than 60 cm square.[5]
2. The extension of tunnels of this type aggravated problems of ventilation and water seepage. Mine workers faced extreme difficulties in carrying ore to the mine openings and in eliminating water from the tunnels. Mining costs were thus in fact increased.
3. Those who had the necessary "live skills," i.e., the excavation experts known in those days as horidaiku [literally, excavation carpenters] and the horiko [assistants who carried out the ore] most often died at a young age from silicosis, a painful lung

disease caused by prolonged inhalation of ore dust which, together with oil smoke from the miners' lamps, thickly polluted the air in the tunnels.

4. It was often difficult to find replacements for mine workers who died from silicosis or other causes. This was partly because miners tended to be part of a "spillover population" which did not fit into any of the four major social classes into which Tokugawa society was rather rigidly divided.[6]
5. Methods of refining the ore were left to the discretion of the subcontracted mine organizers. As in the case of their directing attention exclusively to rich veins, they were primarily interested in refining especially high-quality ore, and did not attempt any technological innovations for the treatment of ores of lower quality.

The above problems are concerned mainly with ore extraction and refining, the central steps in production. These problems continued to exist, in one way or another, along with problems of management. At various times and places, measures aimed at overcoming these obstacles were attempted, but such measures always proved to be only temporary, falling short of fundamental solutions. A major reason for these failures was that whatever changes were made, these never went so far as to reform the basic management system of subcontracting out the work to the traditional yamashi mine operators.

Thus it is evident that the stagnation and relative inactivity of the non-ferrous metal mining industries towards the middle part of the nineteenth century was largely due to problems stemming from imbalances and conflicts of interest in the subcontract management system. However, it came to be generally recognized that paths to advancement could not be opened by continuing to rely on the skills and practices of the past.

Nevertheless, we must note that amidst this situation, the opening of the country to foreign trade during the 1850s brought opportunities to overcome this stagnation in the non-ferrous mining field. Especially

important in this regard was the opening to foreign trade of the port of Hakodate at the southern tip of Hokkaido, Japan's large northernmost island which was at the time sparsely inhabited and still called "Ezo," an old name used also to refer to the islands' "native" population of the Ainu ethnic group. The demand at Hakodate for coal to fuel ships from various countries was growing, and serious attention was being given to plans for developing coal and other natural resources in the interior of this northern island.

With very few exceptions, most of the already existing mines on Japan's main island of Honshu were no longer looked upon as profitable for exploitation, and they were furthermore faced with problems of the types described above. Moreover, in Honshu there appeared to be little prospect for the discovery of new mining areas. The opening of mines in the interior of Hokkaido became the focus of many people's hopes, and accompanying those expectations was a willingness to try new practices to replace the old.

Two items must be mentioned in this regard: (1) the government's employment of foreign engineers and teachers, and (2) the development of mine-related education and exploration which made systematic and scientific use of mine technology.

The two chief administrators stationed in Hakodate by the central government recommended to their superiors in Edo (present-day Tokyo) the hiring of mining engineers from abroad. As a result, the central government, through the intermediary of the United States consul Townsend Harris, in 1862 employed Pumpelly, a 25-year-old geologist and mining engineer, and Blake, an engineer and mine specialist.[7]

The occupations of these two men are worthy of note. The fact that the government brought into its employ two men whose specialities were geology and mining should be interpreted as an indication that it was rejecting the former practices of mine exploration, i.e., the pseudo-science known in Japanese as sansōgaku which derived from the trial-and-error experience of the yamashi subcontractors, and that it

intended to switch to mine exploration and development based on "scientific principles."

We can see, therefore, the great hopes being placed on the new development of mines in Hokkaido. The importance of the Hokkaido mines was in fact such that the geological and mine studies carried out there served as a starting point for the later "redevelopment" of already existing mines on the main island of Honshu during the Meiji period (1868-1912).

Pumpelly and Blake twice visited the interior of Hokkaido and there carried out geological and mine surveys. Their experiences and findings are contained in Pumpelly's book entitled Geological Researches in China, Mongolia and Japan during the Years 1862 to 1865, and in Blake's Geological Map of a Portion of the Island of Yesso [Ezo], Japan (1862).[8]

In the course of the second survey, the two engineers made practical use of chemical explosives at the Yūrappu mine. This event was a pioneering example of the process of innovation about to be experienced throughout the Japanese mining industry, which, as already described, had been suffering from a lack of vigour. Up to that time, virtually the only ore-extracting tools that had been used in Japan's mines had been the mining chisel or gad (tagane) and the sledge-hammer (tsuchi).

Pumpelly and Blake in July 1862 opened in Hakodate a school called the Kōshi Gakkō where they educated Japanese in scientific mining practices. At this school they taught methods of systematic and scientific mine exploration and ore analysis, as well as the necessary theory and skills for successful mine management in all its many aspects. The thoroughness of the training they conducted is suggested by the list of items they brought with them to Japan.[9] These included various types of chemicals and survey instruments, books on mining by Carl Hartmann, Bernard von Cotta, and Carl F. Plattner, Turner's Manual of Mineralogy, and Charles Lyell's Principles of Geology.

The two American mining engineers were accompanied on their two survey expeditions by Ōshima Takatō (1826-1901) and Takeda Hizaburō, students at the mining school in Hakodate who had in the course of their studies built up a close friendship with their teachers. Ōshima, a native of northeastern Honshu, was the son of a doctor who practised western medicine learned from Dutch books imported during the period before the 1850s, when the Netherlands was the only European country permitted to carry on trade with Japan. Before going to Hakodate he had been appointed an instructor at the central government office established in 1855 for translating foreign books.

Takeda was originally from the island of Shikoku. Both he and Ōshima had long been interested in mining and both had in their youth studied modern mining on their own by reading books written in Dutch. Both were eager to receive direct instruction in Hokkaido. They were quick to learn and both played leading roles in the later modernization of Japan's mining industry. Blake recorded for posterity the high hopes he placed in them.[10]

In addition to these two engineers from America, the central government a few years later, in 1866, hired E.H.M. Gower from England, who also was charged with providing guidance for the opening and operation of the Hokkaido coal mines. In 1867 the Satsuma han at the southern tip of Japan's southernmost island of Kyushu hired François Coignet from France to help modernize the Yamagano gold mines.

The changes in mine management and technology which were later carried out throughout Japan used as models these first experiments in modernization, beginning with the Hokkaido coal mines.

II. GOVERNMENT-OPERATED MINES AND THE EMPLOYMENT OF PERSONS FROM ABROAD

The process of establishing modern industries in Japan was greatly influenced by the need to procure gold and silver for the manufacture of coins, as well as by government policies aimed at holding down imports of such minerals as copper, lead, iron, and coal, while promoting the domestic production of iron for military purposes.

Thus the central or local han governments were faced with the urgent need to make significant breakthroughs to improve the efficiency of the mining industry. In 1868 the central government underwent a major change, known as the Meiji Restoration, one result of which was abolition of the local han feudal domains and greater standardization in government functions throughout the country. Because private industrial capital was at the time not yet sufficiently developed, the new Meiji government decided that the best way to promote the mining industry would be to establish government-operated mining companies.

Table 2[11] shows that in the case of non-ferrous metals, government-operated mines were first developed for the production of gold and silver. Some of these mines were large; others were small. The quality of the mined ore varied greatly.

Table 2 also shows that during the eight years from 1868 to 1875, a total of 43 mines were designated for government operation, of which 65 per cent were gold or silver mines. This total included eight copper mines and seven lead mines designated for government operation after 1871. The criteria for selecting these mines seem to have been at first not very well established and the status of ownership and operation tended to change rapidly.

TABLE 2. Designation of Government-Operated Mines (1868-1875)

Year and month of designation	Name and location of mine	Metal produced	Date of termination of operation	Date of sale	Purchaser
Dec. 1868	Ikuno (Tajima-no-kuni: present-day Hyōgo pref.)	Silver		Sep. 1896	Mitsubishi (Gōshi Kaisha)
Feb. 1869	Moriya-mura (Iwashiro-no-kuni: present-day Fukushima pref.)	Gold	Oct. 1869		
Apr. 1869	Aikawa-machi (Sado-no-kuni: present-day Niigata pref.)	Gold		Sep. 1896	Mitsubishi (Gōshi Kaisha)
Apr. 1869	Mitokiya (Shimotsuke-no-kuni: present-day Tochigi pref.)	Gold	Apr. 1871		
Aug. 1869	Kekurano-mura, Shirahama-mura, Hama-mura, Nawaji-mura (Izu-no-kuni: present-day Shizuoka pref.)	Gold	July 1870		
Aug. 1869	Tachizawa-mura, Yudono-san, Gassan-zawa (Ugo-no-kuni: present-day Yamagata pref.)	Gold	Apr. 1870		
Sep. 1869	Sekitani-mura, ana-zawa (Ugo-no-kuni: present-day Yamagata pref.)	Silver	Dec. 1870		
Nov. 1869	Kosaka (Rikuchū-no-kuni: present-day Akita pref.)			Aug. 1884	Kuhara Shōzaburō = Fujita-gumi
Apr. 1870	Aono-mura (Izu-no-kuni: present-day Shizuoka pref.)	Gold	July 1870		
Apr. 1870	Gobōno-mura (Ugo-no-kuni: present-day Akita pref.)	Gold	Oct. 1870		
June 1870	Jinego-mura, Tabamatsu, Ashinobe, Taisei, Tagouchi-mura, Sakana-zawa (Ugo-no-kuni: present-day Akita pref.)	Gold & silver	Dec. 1870		
Feb. 1871	Towada (Rikuchū-no-kuni: present-day Akita pref.)	Silver			
Nov. 1872	Kami-izumo-mura (Izumo-no-kuni: present-day Shimane pref.)	Copper			
May 1873	Oppu, Hakkō (Mutsu-no-kuni: present-day Aomori pref.)	Copper & lead	May 1874		
May 1873	Hosokura (Mutsu-no-kuni: Present-day Aomori pref.)	Copper & lead	Dec. 1873		
June 1873	Utōgeura (Izumo-no-kuni: present-day Shimane pref.)	Copper	Oct. 1873		

Year and month of designation	Name and location of mine	Metal produced	Date of termination of operation	Date of sale	Purchaser
July 1873	Handa (Iwashiro-no-kuni: present-day Fukushima pref.)	Silver		May 1874	Godai Tomoatsu
Aug. 1873	Obira, Uchinokuchi, Kiura (Bungo-no-kuni: present-day Oita pref.)	Lead & tin	Mar. 1874		
Oct. 1873	Ōkuzo (Ugo-no-kuni: present-day Akita pref.)	Gold	June 1879		
Oct. 1873	Magane (Rikuchū-no-kuni: present-day Akita pref.)	Gold	June 1879		
Nov. 1875	Ani (Ugo-no-kuni: present-day Akita pref.)	Gold & silver		Apr. 1885	Furukawa Ichibei
Nov. 1875	Mukai-yama, Hachimori (Ugo-no-kuni: present-day Akita pref.)	Gold & silver	June 1877		
Nov. 1875	Yabitsu, Daira (Ugo-no-kuni: present-day Akita pref.)	Gold & silver			
Nov. 1875	Hosoji (Rikuchū-no-kuni: present-day Aomori pref.)	Copper & lead			
Nov. 1875	Kiranuka, Kotsunagi (Mutsu-no-kuni: present-day Akita pref.)	Copper & lead	Sep. 1876		
Nov. 1875	Kagoyama Seikōjo (Mutsu-no kuni: present-day Akita pref.)	Copper & lead			
Nov. 1875	Kawaguchi, Aketorizawa (Ugo-no-kuni: present-day Akita pref.)	Silver & copper	Aug. 1876		
Nov. 1875	Arakawa (Ugo-no-kuni: present-day Akita pref.)	Silver & copper		Oct. 1876	Furukawa Ichibei
Nov. 1875	Innai (Ugo-no-kuni: present-day Akita pref.)	Silver & copper		Jan. 1885	Furukawa Ichibei

Source: Meiji zenki zaisei keizai shiryō shūsei, vol. 17.

Note: The above list includes only non-ferrous metal mines.

It should be noted that already during this initial eight-year period of the new policy of designating government-operated mines, many such mines were "sold to private operators" and that many of the mines are recorded as having been "abandoned soon after designation" or as having remained "unexploited."

The new Meiji government, which took office in 1868, was eager to increase its capacity to assure a supply of gold and silver for the

manufacture of coins and to make any necessary changes in the currency system, which had been in a continual state of disorder during the last years of the Tokugawa period. The new government was intent upon increasing its authority through a new unified monetary system (to replace the many separate systems which had been in use during the former period of han feudal domains). There was also the urgent task of making a stable response, following the opening of certain Japanese ports in the 1850s, to the type of international trade which formed a part of the worldwide capitalist system of the time.

The government took great pains to achieve these goals. Some of its more important actions in this regard were the establishment in 1868 of control over the buying and selling gold, silver and copper, followed in 1872 by a "set of instructions" on mining and the next year by the Japan Mine Law aimed at preventing foreign capital from gaining control over natural resources and at establishing the principle of national ownership of mines. In addition to this series of legal steps, in 1870 the new government established a Ministry of Industries (Kōbushō) as an administrative organ responsible, among other things, for mines.

The government was not unaware of the need to work out criteria for deciding which mines should be government-run and for what purposes. Finance Minister Ōkuma Shigenobu (who later founded Waseda University) asked the French engineer Coignet for detailed advice on the government-operated mines and Coignet in 1871 presented a report which recommended the following:[12]

1. A total of six mining areas should be selected for government operation, and these mines should be made to serve as models for privately operated mines.
2. The six model mining areas should include the Ikuno silver mines (already government-run), the gold mines on Sado island in the Japan Sea near the city of Niigata, and mines selected as being the most promising for the production of lead (with an admixture of silver), tin, coal, and iron, respectively.
3. A number of specialists and engineers should be brought from Europe

to give necessary instruction in various aspects of mining and to impart their knowledge to Japanese.

4. The model mines should develop management methods patterned after efficiently run European enterprises (whether private or public) and should produce substantial returns.

Inoue Kaoru, a top government official concerned with financial affairs, presented in January 1873 these recommendations:

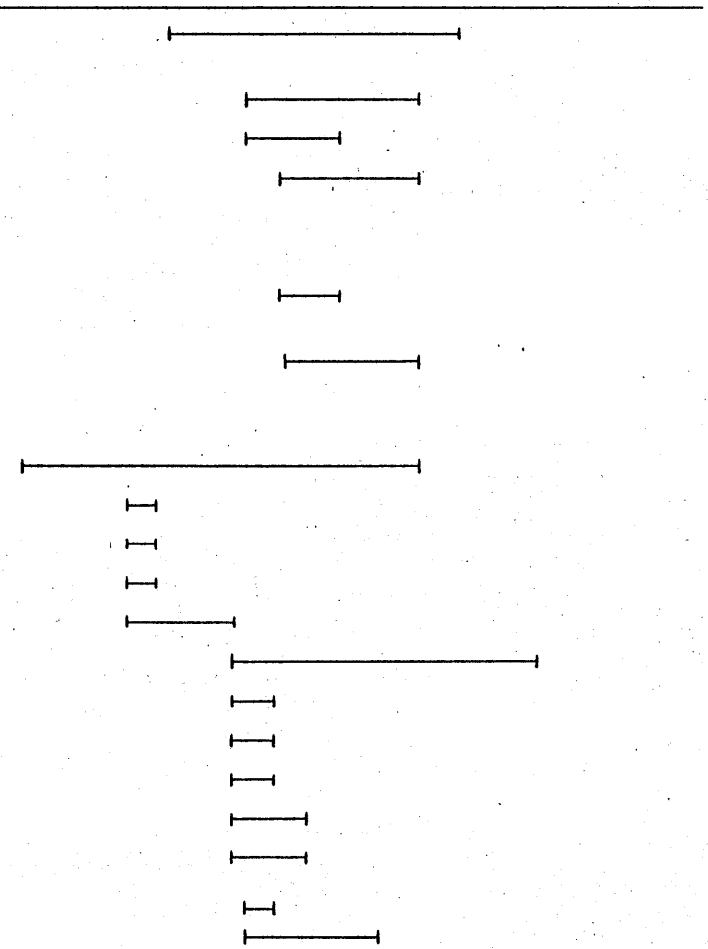
> In discussing the various mines in our country, we may say that despite differing degrees of prosperity, in general they ought to be considered the country's most important industry and ought to produce large profits. An office in the Ministry of Industries has already been set up to deal with the above matter. However, this office's budget is hardly sufficient (to meet the necessary monetary outlays) and in such cases it is difficult for the necessary work (of the mines) to prosper, and the benefits therefrom are consequently very small. The mines in fact are unable to produce enough for the manufacture of coins. This is a matter of utmost regret. Gold, silver, and copper are all now in urgent demand for the casting of (metal) currency. Therefore, it is my wish that ten optimum locations be selected and planned for the development of government-run mines and that all the necessary expenses for developing these mines be provided from a corresponding reserve fund independent of the ordinary government budget. I should hope that the products of these mines, after refining and casting, be either made into metal currency or sold to have the profits therefrom added each year to the reserve fund. I hope that for these purposes the utmost efforts will be made and that the wonders and benefits of nature will thus be greatly promoted.[13]

These recommendations were adopted and, as a result, by around 1877 the previous lack of order and discrimination in the selection of mines to be operated by the new Meiji government was largely corrected and an up-to-date system of government-operated mines became established.

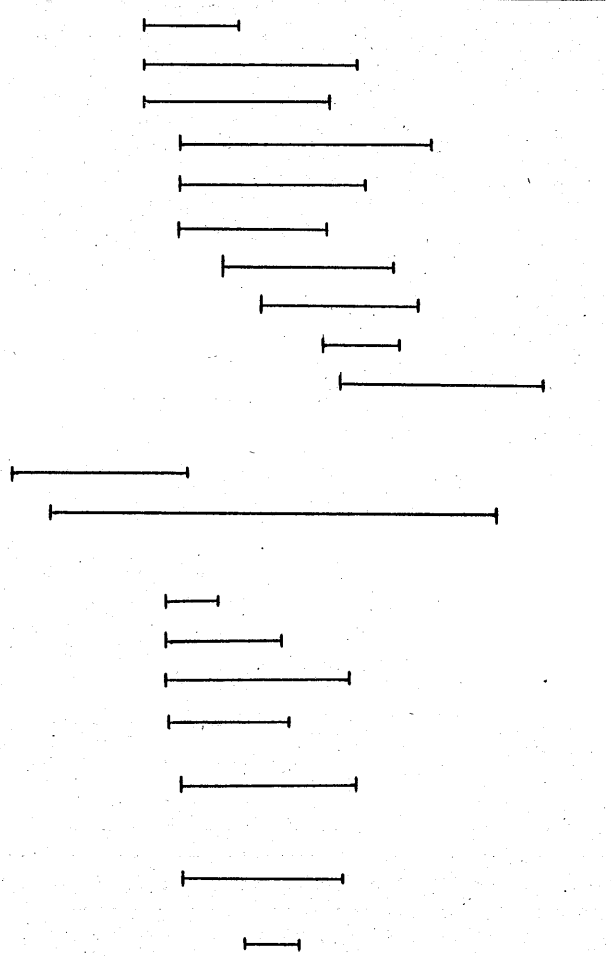
The Meiji government employed at these mines a number of persons invited from abroad, numbering 78 in all, of whom 50 worked in coal and other non-ferrous mines. Their names, occupations, salaries and terms of service are shown in Table 3.

TABLE 3. Foreign Employees at Government-Operated Non-ferrous Metal Mines (1868-1883)

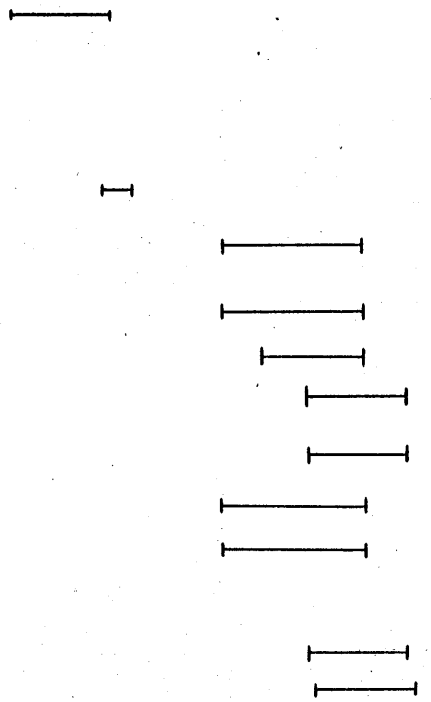
Place of work	Nationality	Name	Job description	Monthly salary	Period of employment
Ministry of Industries Head Office	English	J.C.H. Godfrey	Chief mining engineer	¥ 1,000	
	English	Frederick Hayes	Secretary	260	
	German	Georg Martin	Instructor	260	
	English	William Bell Davis	Instructor, excavation engineer, and expert in mineral analysis	365	
	English	Joseph Walters	Assistant chief mining engineer	415	
	English	Robert Freshville	Instructor, mining engineer, metallurgist	370	
Ikuno	French	François Coignet	Mining engineer	800	
	French	Piquet	Miner	91	
	French	Ruby	Miner	91	
	French	Pauli	Miner	91	
	French	Denis Sevoz	Geologist	570	
	French	Emile Mouchet	Geologist	700	
	French	Alphonse Palisse	Bricklayer	120	
	French	Malraux	Miner	130	
	French	François Allain	Miner	130	
	French	Antoine Géraud	Miner	130	
	French	Pierre de Heunard	Miner	130	
	French	Lescasse	Geologist	300	
	French	Augustin Henneton	Medical officer	350	



Place of work	Nationality	Name	Job description	Monthly salary	Period of employment
	French	Jacques Legrand	Smelter worker	¥ 150	
	French	Jean Lustemberger	Mechanic	200	
	French	Claude Verner	Mechanic	200	
	French	Paul Lerme	Smelter worker	120	
	French	Léon Sisley	Geologist	300	
	French	André Bosch	Miner	103	
	French	Joseph Lustemberger	Instrument specialist	200	
	French	Jean Lenoir	Miner	200	
	French	François Maillet	Medical officer	300	
	French	Repiquet Lamy	Forge worker	150	
	French	Charles Boudoir	Instrument specialist	200	
Sado	English	E.H.M. Gower	Ore preparation expert	600	
	English	James Scott	Instrumentation and ore preparation expert	280	
	English	James Dale	Miner	80	
	English	John Simmons	Miner	80	
	English	Thomas Treloar	Miner	120	
	American	Alexis Janin	Mining and ore preparation expert	525	
	German	Adolf Reh	Tunnel excavator	400	
Kosaka	English	Thomas Treloar	Miner	-	
	German	Curt Adolf Netto	Mining and ore preparation expert	450	
	German	Charles Hagmaier	Instrument specialist	250	



Ōkuzu	English	Thomas Treloar	Miner	¥	-
	American	Robert T. Carlyle	Mining, instrumentation, and ore preparation expert		415
	English	Robert Freshville	Instructor and mining and ore preparation expert		-
	English	William Thomas Brown	Instrument specialist		150
Ani	German	Adolf Mezger	Chief of instrumentation		500
	German	F.W. Reichl	Mine foreman		150
	German	W. Heise	Mechanic		250
	German	von Weyer	Assistant mining engineer		250
	German	Wilhelm Callas	Smelting engineer		300
Innai	German	Oswald Pfeiffer	Mine foreman		150
	German	Christian Bansa	Chief of instrumentation		500
	German	W. Heise	Mechanic		-
	German	Fritz Schwinn	Ore-washing foreman		125
	German	B. Roesing	Smelting eningeer		300



Source: Meiji zenki zaisei kaisei shiryō shūsei.

Note: Compiled by the author and based on pages 91-96 of Kōbushō Enkaku Hōkoku.

Although the practice of employing persons from abroad was begun by the government-operated mines, it was soon copied by privately operated mines as well. For example, an American engineer was hired by the Osarizawa mine; Louis Larroque (France) by the Besshi copper mine on the island of Shikoku; Paul Sarda (France) by the Iwami Ōmori silver mine; and Paul Ogier (France) by the Yamagano gold mine.

III. FOREIGN EMPLOYEES' IDEAS ON MODERNITY

Much remains today that we would like to know in more detail about the activities of the foreign employees who came to work at mines in Japan in the early Meiji era. However, some information may be gleaned from the various reports and prospectuses they left behind which tell us about their periodic observations and surveys and the start of new mining operations.

For example, Coignet wrote "Note sur la Richesse Minérale du Japon" as well as an account of "policies of mine administration in Japan" and a report on the Ani copper mine. Other interesting accounts include "On Mining and Mines in Japan" by Curt Netto and a translation of notes on the latter's lectures at Tokyo University published by the Ministry of Education in 1883 under the title Nesshi yakingaku [Netto's metallurgy]; a report on the Besshi mines by Larroque; a report on the Ani mines and "Einiges über Bergbau und Hüttenwesen in Japan" [Some thoughts on Japanese mining and metallurgy] by Adolf Mezger; "Mittheilungen aus Innai" [Report from the Innai mines] by B. Roesing; "Reise nach Kosaka und Aufenthalt daselbst" [A journey to and stay in Kosaka] by C. Hagmaier; a report on the Oppu copper mine by E. Naumann; and detailed accounts of visits to mines in central and northeastern Japan as well as along the Japan Sea coast by J. Godfrey.

An analysis of these various reports shows that the authors shared a common awareness that modernization meant more than mere technological innovations. Without exception, the type of "modernization" which they helped plan and in which they played a leading role in putting into practice did not neglect essential changes in the system of management.

The sort of modernization which they planned and guided invariably aimed at replacing the old system by which the opening and operation of mines had been delegated to subcontractors (yamashi, kanako, etc.) who kept under their control the necessary labour force with its knowledge and special skills and who also acted as middlemen in buying and reselling ore and refined metal.

The foreign employees in all cases wished to replace this old system by one in which the yamashi and kanako would be absorbed into positions which would support the work of the new owner-operators who would ideally be well acquainted with both the theory and the practice of advanced mine management. The foreign employees further proposed that in the new systems the mine-related labourers — i.e., the specially skilled horidaiku miners and their horiko assistants, and skilled traditional ore-refining specialists known as fukidaiku and their fukiko assistants — be given specific wage contracts to replace the former dependency on superiors with its attendant lack of a fixed income.

Significantly, the new concepts proposed centralizing control over all production and management activities in the hands of the new owner-operators, whether government or private.

In his "Note sur la Richesse Minérale du Japon," written at the Ikuno silver mines in 1874, Coignet noted that in the second half of the sixteenth century, which had been a brief period of unrestricted trade and intercourse with Europeans, older mining and metallurgical practices underwent a technological change — in the case of mining, a change from the open-cut method to the gallery (tunnel) method, and in the case of refining, the adoption of cupellation and western methods of extracting copper. As a result, the mining industry rapidly developed. However, he also noted that the industry flourished for only a century and then gradually declined until 1869, the second year of the new Meiji government. Coignet ascribed this decline in productivity to the following causes:

1. The use of chemical explosives to excavate hard rock formations was

unknown, and since the only excavating tools were the mining chisel (tagane) and pickaxe (tsuchi), only areas with especially rich ore and only relatively "soft" and easy-to-dig areas were mined. Areas which met both these conditions tended to become exhausted rather quickly.

2. Channels for water drainage often had to be cut through hard rock for efficient operation, but because of high construction costs the practice of opening such drainage channels was gradually abandoned. The only mechanical devices for eliminating water were bamboo pumps and in places where these could not operate efficiently, water seepage in the tunnels made mining operations extremely difficult or impossible.
3. The tunnels were very small (60 cm wide and 90 cm or sometimes only 60 cm high). They were also winding and unsystematically located, making it extremely difficult for the horiko workers to carry out the ore, especially from the deeper tunnels.[14]

Coignet noted that in the traditional processes of ore selection and refining much ore had been discarded which by more modern treatment processes could have brought profitable yields of gold and silver.[15]

Most of this "waste" from the mines was piled up near the tunnel entrances. Coignet writes that until not long before the time of his observations, ore which contained less than 7 per cent of refinable metal was discarded as being too expensive to refine. He mentions that he ran a test on some discarded ore which he happened to obtain from a tin mine about 20 km southwest of Kagoshima and found that it contained some 75 gm of gold and 1,279 gm of silver per tonne. On the basis of these results he judged that it would be feasible to introduce western methods to redevelop mining and refining throughout Japan.[16]

In his opinion, the introduction of western operations should not be limited to machines and technology in the hands of foreign employees such as himself, but should include the training of Japanese technicians, who should be made well acquainted with the new methods.

He then proposed setting up at the Ikuno mines (to which he was attached) a "training and experiment centre" to train Japanese mining engineers. The institution which Coignet envisaged for Ikuno, but which appears never to have been realized in practice, aimed also at the dissolution of the old and ineffectual yamashi-kanako subcontract system and putting all production activities directly under the control of government owner-operators.

The same need for training courses was also pointed out by Netto at the Kosaka silver mines and by Mezger at the Ani copper mines. Both set to work to give concrete form to their proposals.

Netto, who directed the modernization process at the government-operated Kosaka mines, noted in his account of Japanese mines that, in general, the mine owners purchased the ore from "middlemen" who on the one hand controlled groups of miners and at the same time sold the ore produced at prices set according to the proportion, by weight, of metal. He writes as follows:

> The decisions as to which miners will excavate at which places and by what methods are in the hands of the middlemen, and the latter, being wholly driven by personal greed, are interested only in excavating soft areas in search of especially high-quality ores, while they avoid and pay no attention to hard [rock] areas.

Netto considered that the mine owners' authority over these middlemen was not being sufficiently well exercised, and concluded that "the subcontract system is the greatest evil in the mining industry."[17]

Mezger, who was employed to direct the modernization process at the government-operated Ani copper mines in 1879, wrote a report which greatly revised some of the plans for the mine which had earlier been drawn up by Coignet.[18] For example, due partly to budgetary restrictions, Mezger's plans omitted Coignet's ambitious proposal for a large refining plant on the coast of the Ōga peninsula which would have used coking coal brought by ship from the Miike mines in Kyushu and which would have refined ore from several different mines in Akita prefecture.

Mezger's report, while long (22 chapters) and detailed, set forth in its preface the problem of the traditional subcontract system. In his preface Mezger states:

> What I have especially paid attention to is the matter of subcontracting. Insofar as the system has been a custom in the mining industry for several hundreds of years, it is by no means with an easy heart that I set to work to abolish it. However, at this time, when it is necessary to make specific plans for developing the mining industry and to plan for new installations, this problem cannot be avoided.

Problem areas to be reformed are pointed out in detail in the third and ninth chapters of the report, which deal with "control and management."

Mezger notes:

> In Japan, if one compares officials at government-operated mines who are in charge of business procedures with those in charge of technology, the authority of the former is superior. The scope of the technical officials' authority is only to check ore veins, leaving their actual exploitation to subcontractors. They only become involved again at the time of purchasing the ore which has been mined and selected by these subcontractors.

Mezger goes on to say that "the subcontractors throw away ore that should be quite suitable for refining, losing half of the usable ore in the selection process." He concludes that "mine operation by subcontractors by no means promotes the development of mining but, on the contrary, impedes it."

As a means of eliminating the subcontract system, he proposed dividing mine officials into two separate sections: technical and general affairs. He suggests that the two sections be jointly controlled by a superior-ranking person familiar with the duties of both. Officials of the technical section should direct the management of the entire course of production, including mining, ore selection, and refining.

He proposed that the refining sector should be mechanized and put firmly under the control of the mine owners (i.e. the government).

Former yamashi and kanako subcontractors should be made to assist in excavating ore which had previously been neglected as being of too poor quality, and should thus be made to assist in providing ore in quantities which would meet the capacities of the mechanized refining technologies. Washing and concentration plants should, he suggested, accept ore only in batches of at least five tonnes, while smelters should accept batches of at least one tonne.

Purchasing transactions should be calculated according to prices set by the standard Mansfeld table for ore assays, developed in Germany. Not only the former subcontractors, but also the manual mine workers (horidaiku and horiko) who had been subordinate to them, should be put under the effective control of Japanese engineers and skilled workers well versed in all aspects of modern mine technology.

These proposals to have the mine owners (in this case, the government) take firm hold of the refining sector, set minimum quotas for ore volumes, and set prices according to scientific standards, were naturally aimed in large part at increasing metal production by eliminating the old practices of excavating only particularly rich ore veins and throwing away "low-quality" but still usable ore in the washing and selection (concentration) processes. But they were also aimed at the dissolution of the yamashi-kanako subcontract system which, with its antiquated hand-excavation methods using only the mine chisel and pickaxe, was expected to encounter difficulty in meeting the requirements of mechanized refining. It was judged that to gain a firm grip on the refining sector would be a major breakthrough on the path to more widespread modernization and would contribute to the dissolution of the subcontract system.

The above proposals were also based on the fact that, in general, the subcontract system was less firmly rooted in the refining sector than in the mining (excavating) sector, where an immediate transition to more modern methods would generally be more difficult.

It should be noted, however, that the subcontract system tended to vary

according to the type of metal being mined. For example, in Japan's silver mines, to a greater extent than in other types of mines, subcontractors had traditionally tended to monopolize not only mining as such, but also the concentration and refining processes.

In any event, in the case of the Ani copper mines, Mezger estimated that from one to two years would be necessary to bring all aspects of production and pricing under the control of the mine owners, namely the government.

After finishing his term of employment at the Ani copper mines, Mezger in 1882 visited the Kosaka silver mines, whose modernization he had earlier directed, and then, beginning in September 1882, he for one year replaced Netto (who returned on leave to Germany) as lecturer on mining and metallurgy at Tokyo University. In his lectures he gave many specific examples, taken from his experiences at the Innai and Ani mines, of the dissolution of the yamashi-kanako subcontract system. He also discussed various problems in the overall process of modernized production, especially in the modernization of the refining sector.

Still another example of the way in which the above-described yamashi-kanako subcontract system had caused stagnation in Japan's mining industry is seen in the case of the Besshi mines (on the island of Shikoku), which had since 1691 been Japan's largest copper mines.

According to a history of these mines,

> One reason why all mining operations in this country were unable to show progress during the latter part of the Tokugawa period was that mining operations were impeded by water seepage. Another reason is that there was a lack of [good] passageways for transporting ore. The only tunnels for mining and transport were extremely small and required exceedingly great amounts of time and labour [to traverse]. The operators were not willing to bear the costs [necessary to remodel the tunnels]. The Besshi copper mines were no exception. Without eliminating the inconvenient working conditions in such mines and without remodelling the facilities within them, no hope can reasonably be put in a

> continuance of operations, regardless of how complete the facilities outside the mines may be. . . .

In the course of its efforts to overcome these conditions at the Besshi copper mines, the Meiji government, although not the owner of the mines, ordered Hirose Saihei, a top manager of the privately owned mining company, to visit the Innai silver mines to receive instruction in western management practices from Coignet. On Hirose's suggestion, Larroque was in 1874 employed at the Besshi mines, where he set to work at planning the mines' modernization. Larroque's suggestions, which appear to have met his employers' expectations, were principally concerned with the following four topics:

1. facilities inside the mines, especially the opening of new, methodically planned horizontal and vertical tunnels (galleries);
2. roads, railroads, and other transport facilities;
3. installations for ore refining, construction of a smelter, and manufacture of bricks needed for such construction;
4. new mining methods and the installation of ore-pulverizing machines and other modern equipment.[19]

It is worth noting that in this case, too, the plans for modernizing and centralizing the refining sector, with the building of a central smelter, were an important foundation for eliminating the yamashi-kanako subcontract system and turning over to the mine owners control of the entire process of production.

IV. PROGRESS OF MODERNIZATION

Modernization in Japan's non-ferrous mining industry began with the modernization, i.e. the mechanization, of the refining process. This fact is clearly pointed out in a book on Japan's mines (translated into Japanese under the title Nihon kōzanhen) by the foreign employee Curt Netto.

Writing in 1879, Netto discusses those mines, both government and privately operated, which had until then "put the new methods into practice." His description of the sectors of production in which modernization began at each mine can be summarized as follows:

1. At the gold and silver mines on Sado island, there were introduced an ore refinery for preliminary processing, an extraction plant for a higher degree of processing, and an amalgam process using iron pans. These facilities were originally set up by employees from abroad but were at the time of writing being operated wholly by Japanese.

2. At the Ikuno silver mines in the northern part of present-day Hyogo prefecture, modernization began with the introduction of 100 rotating stampmills driven by waterhweels, together with a refinery using a Rittinger table (a type of jigger for separating different sizes of ores) and a Freiberg-type amalgam method making use of barrels. Twelve persons from France had earlier been employed, but their number at the time of writing had been reduced to eight.

3. At the Ōkuzo gold mines in present-day Akita prefecture, modernization began with the introduction of the California-type amalgam method using iron pans, together with the Hungary-type stamp

amalgam method using a kind of mortar. Ten waterwheel-driven iron stampmills for pulverizing ore were also introduced. The equipment had been first installed by engineers from America, but at the time of writing it was being wholly operated by Japanese.

4. At the Kosaka silver and copper mines, also in present-day Akita prefecture, a smelter using both the Ziervogel and the Hunt-Douglas metallurgical processes had been introduced. The work of smelting had been initiated by engineers from Germany but was at the time of writing being done wholly by Japanese. The Ōkuzo and Kosaka mines had originally belonged to local han governments, and after the Meiji Restoration of 1868 both the ownership and management of the mines passed into the hands of the new central government, which took the initiative in introducing new mining methods.

5. At the Yamagano gold mines in present-day Kagoshima prefecture, modernization began with the introduction of the California amalgam method and the installation of ten iron stampmills for pulverizing ore. French engineers were still in charge of the (refining) operations.

6. At the Handa silver mines in present-day Fukushima prefecture, modernization began with the introduction of a mill using wooden ore-pulverizing pestles fitted with iron rings, together with a Freiberg-type amalgam method using barrels. At the time of writing, the manual operators were all Japanese, but they were employing European methods.[20]

The above summary shows that an important initial stage in mechanical refining was the introduction of iron machinery for crushing and pulverizing and apparatus for concentrating the pulverized ore. And various amalgam methods as well as the Ziervogel and Hunt-Douglas smelting processes were adopted in order to raise the degree of purity of gold, silver, copper, and other metals.

In his book, Netto notes that although tests in 1875 of a new amalgamation refining process at the Sado gold mines were successful,

the total output of refined metal did not increase as fast as it might have, due to the fact that the still backward mining methods did not supply enough ore to meet the capacity of the new refining process. It is obvious from Netto's first-hand account that it was indeed in the refining sector, not in the mining sector, that the modernization process had its beginning.

It should be noted that in the case of mercury amalgam processes, different mines, in a rather uncoordinated way, introduced and adopted different methods, e.g. the California pan method, the Freiberg barrel method, and the Hungary stamp methods. This situation reflected the fact that, as shown in Table 3, the foreigners employed at the various mines were of a variety of nationalities (Britain, USA, France, Germany) with a variety of technological traditions. It also reflects the fact that Japanese of the time lacked sufficient ability to make technological choices on their own or to coordinate and standardize the types of new technologies adopted.

The California-type method, by which amalgams were made in pan-like containers, was introduced on Sado island by Gower from Britain and A. Janin (USA); at the Ōkuzo mines by R. Carlyle (USA); and at the Yamagano mines by the Frenchman, Ogier.

Ogier came to Japan in 1877 with a strong recommendation from Coignet, and in the following year was employed by the Yamagano mines to direct their technological development. Most probably on Coignet's advice, he had on his way to Japan stopped in California and Nevada where he helped open new veins of gold ore at the mines around Virginia City, Gold Hill, and Glass Valley. He also had the opportunity to observe and study the mechanical apparatus and details of the salt treatment method through which gold is separated from ore through the addition of salt. Ogier's various experiences in California had an important effect on the guidance which he imparted while employed at the Yamagano mines.[21]

In Europe, the study of mining and especially of metallurgical

technology may be said to have developed and expanded through much of the continent and later through much of the world as a result of the "silver rush" which took place in the mid-twelfth century around Freiberg, in the southern part of the present-day German Democratic Republic.[22] It is not surprising then that despite the fact that Coignet (who had studied at the mining school in St. Etienne) had worked in California, he chose the familiar Freiberg amalgam method (from which the other amalgam methods developed) to be tried and then adopted at the Ikuno mines. The Freiberg method was later also adopted at the Handa mines.

It is interesting to note, however, that prior to his arrival in Japan, where he was originally employed by the Satsuma han in 1867, Coignet had had experience in surveying gold mines in California, and that as a result of this experience he ordered much of the necessary small-scale refining apparatus for the Ikuno mines from the United States, which had greatly developed its metallurgical technology in the course of the mid-century "gold rush" in the Western states.[23]

The Handa mines were privately owned by the financier and politician Godai Tomoatsu, who had formed a close personal friendship with Coignet. It is no surprise, then, that both direct and indirect guidance from Coignet was requested. Refining and other facilities at the new Handa mines are described as follows:

> My Handa silver mines use an amalgam method patterned wholly after that of the government-operated Ikuno silver mines. At the time my mines opened in 1874 they had a dressing plant, an ore-crushing plant with 15 stampmills capable of pulverizing approximately 1,200 kanme (3,500 kg) of ore in 24 hours, a roasting plant, a reverberatory furnace which measured 1 jō (about 300 cm) in length and 4.5 jō in length, an amalgam plant with two amalgamation barrels, and also a plant for the end-production of silver, an office, workshops, and warehouses, all of them newly constructed.[24]

Coignet visited the Handa mines in 1876 and gave direct guidance on all stages of production.[25]

The following quote describes the introduction at the Kosaka mines of the Hunt-Douglas and Ziervogel methods for extracting silver.

> When Netto assumed his post as chief processing engineer at the Kosaka mines in 1873, he changed the design of the smelter to the Mansfeld type since the previously used dry-type refining methods had not given a very high yield in relation to the costs incurred. Plans were thus laid to reduce the consumption of charcoal fuel and to adopt the wet-type method for the treatment of matte. By this new method, the matte formed was pulverized and then roasted in a specially constructed furnace, in which the silver and lead contents were transformed into water-soluble sulphates. First a copper plate was introduced into the solvent to retrieve silver precipitate by the Ziervogel method, and then an iron plate was introduced to collect copper precipitate by the Hunt-Douglas method. (See Figure 1.)

Thus, the type of refining technology introduced at the Kosaka mines differed from that introduced at other mines. The reason for this was the peculiar quality of the ore at Kosaka, consisting of a mixture of three types of ore: black, yellow, and siliceous.[26]

As previously mentioned, the modernization of the non-ferrous mining industry in Japan centred on the mechanization of the refining sector. However, this mechanization process by no means proceeded smoothly.[27] As explained in more detail later, there was a stubborn repetition of actions aimed at protesting against or obstructing the modernization taking place under the guidance of the foreign employees. Such actions were carried out not only by the yamashi and kanako sub-contractors, but also by manual labourers subordinate to them.

The foreign employees, however, persisted, despite many hardships, in pushing forward the modernization of the refining sector. They also prompted the training of Japanese to take a front-line role in the modernization of the mining and concentration (ore dressing) sectors, where improvements had long been neglected by the yamashi and kanako sub-contractors. The foreign employees were convinced that only by the proper training of such Japanese workers would it be possible eventually to eliminate the yamashi and kanako traditional middlemen and bring all aspects of production effectively under the control of

the mine owners, whether government or private.

For example, in making plans for the redevelopment of the Ikuno silver mines, Coignet already in 1869 foresaw the need to train Japanese mining engineers, and in the same year received permission to establish a mining school. By 1872 the school had trained a total of 15 engineers.

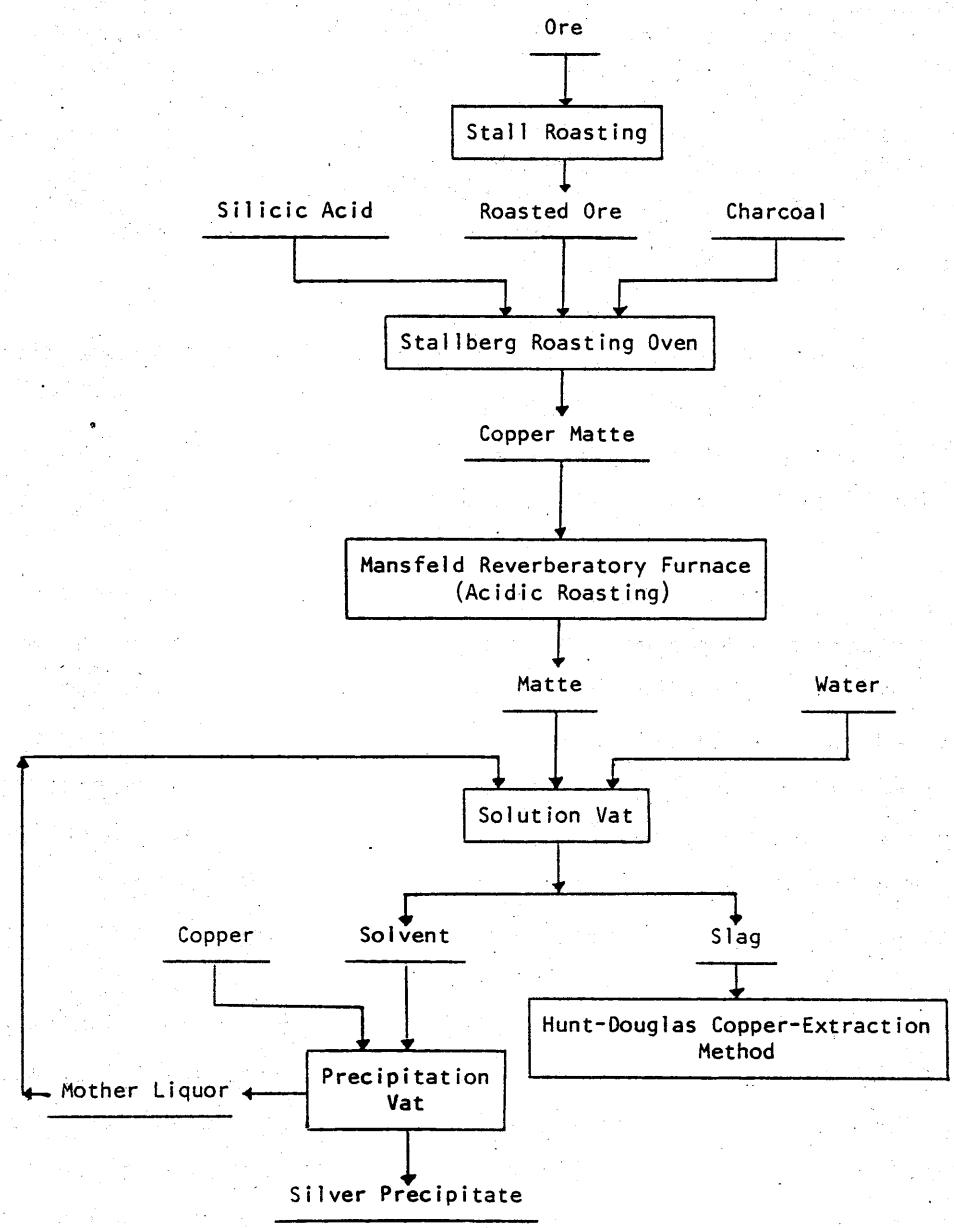


FIG. 1. Refining System at Kosaka Mines

Source: Meiji kōgyōshi kōgyō-hen, p. 404.

It is unknown what became of the school afterwards or what sort of curriculum it had, but in Coignet's "letter of proposal" [asking for permission to establish the training facility] he wrote that "to set up equipment and machinery in the Kanakase mining sub-district of the Ikuno region, to contribute thereby to industry and to use it for the education of students, should make it possible to train a number of mining specialists and to promote their work."[28] From the foregoing, it may be assumed that some sort of on-site training in mechanical refining methods was given.

The Meiji government issued a directive to prefectures throughout the country, ordering that students be sent to Ikuno. However, the students who did attend Coignet's school were for the most part from the Ikuno area itself (present-day Hyogo prefecture) or such nearby prefectures as Okayama, Hiroshima, and, according to one source, Kanazawa. The trainees were given "scholarships" in the form of rice by their native prefectures.[29]

At the Ani copper mine which was in 1875 designated a "government-operated mine," managerial reforms were attempted by the government-appointed head supervisor, Ichijō Motoi. However, the attempted reforms tended to stagnate because of opposition from the yamashi and kanako middlemen who tried to maintain the old ways that had prevailed since the pre-1868 Tokugawa era. As a means of trying to overcome the old mining practices, the managers of the Ani mines in 1876 sent 13 miners, under the leadership of Tanaka Yoshitarō, a lower-ranking government official who was ordinarily posted at one of the six Ani mining areas, to the Ikuno silver mines in order that they might learn through direct, concrete experience how to switch to more modern methods.[30]

The practice of sending mine workers to the Ikuno mines was also seen in the case of the privately operated Besshi copper mines on the island of Shikoku. Since 1691 the management of the Besshi copper mine had been entrusted, generation after generation, to the Sumitomo family. This management tradition was allowed to continue by the new

Meiji government after 1868. In 1868 and again in 1871, the mines' general manager, Hirose Saihei, personally visited the Ikuno mines to receive direct instruction from Coignet concerning mining and metallurgy and western managerial practices. This experience influenced the decision in 1879 to employ Larroque as an adviser at the Besshi mines.[31]

In the case of the Ani copper mines, the results of the experiment of sending workers to the Ikuno mines for on-site training appear to have been insufficient, and efforts to modernize mining and managerial practices continued to falter. However, in 1879 efforts were begun in earnest to modernize along lines suggested by the German engineer Mezger. Conditions at the Ani mines at that time are described in a report by Kitsunezaki Tominori, head of the refining division, as follows:[32]

> Because those at the mines were accustomed only to old makeshift methods and had no thought of promoting new methods, a group of some 14 or 15 miners was made to learn the new techniques, and those among them who came to understand the new methods were made foremen (kōfu-gashira) to direct the work of other miners. In order to train these foremen to work in all the various mines [in the Ani area], a foreman who was a foreign employee, a German named Reichl, was sent to the Mukai silver mine where he gave instruction in mining practices and brought renewed prosperity to that mine. The Mukai mine is located on the opposite bank of the Ani river and has rich veins of gold, silver, and copper at a distance of about ½ ri [about 2 km] from the mine's head office. It is said that when the mine in question was first opened, the surrounding region was extremely prosperous, but now there is only a single small hamlet known as Ginzan-chō. There are three large veins of ore, which go by the names of Detokindate, Ōkindate, and Unjōhi. . . . According to oldtimers, what had caused the Mukai mine to cease operation was the fact that excavations had been done in an unplanned, makeshift way, with the result that the tunnels became filled with water, and even though it was known that there was good ore in the depths of the mine, it had become impossible to apply mining techniques. It is said that when the Ono-gumi (a Kyoto-based group of merchants and entrepreneurs) was operating there some years ago, it had excavated some good ore, but that it ceased operations because of the very poor condition of the tunnels, a demerit too great to overcome. The recent plans to revive the mine aim at improving the tunnels, facilitating ore transport, pumping out accumulated water, and educating mine foremen who will be able to excavate good ore.

The on-site training thought necessary for modernization in the mining sector in the Ani region was completed in December 1880.[33] According to a government report, starting in November 1879 "government personnel and miners who had received instruction in mining at the Mukai gold and silver mine were sent to various mining sites, including the Daira mine, where they set to work to improve mining practices. In the process, the traditional operators, i.e. kanako, are gradually being eliminated."[34] As a result, the entire range of production factors (including on-site management) at the Ani mines was being returned to the control of the mine owners, in this case the government.[35]

There are many other examples of deliberate efforts to break up the old managerial system by which contractors and subcontractors (yamashi and kanako) had monopolized production in the search for short-term profits. One example is that of the Innai silver mines, described below.

As of 1876, the management system used at the Innai silver mines was one by which, in spite of the fact that the mines had the previous year been designated as "government-operated," the government was continuing to purchase from the kanako subcontractors metal which the mine workers (who were subordinate to the kanako) had themselves refined at their own homes to the highest state of purity possible with the traditional technology. (Such silver was known as yamabukigin and had a slightly yellow colour due to remaining impurities.)

Because this system was proving inefficient and unprofitable for the government, the latter began to search for means of improvement. After a period of study, in 1878 the government set up an ore concentration plant to which all the ore excavated under the kanako system was brought together in one place and where the processes of concentration, washing and refining were carried out under direct government control. However, the government was not without certain fears in regard to the reform.

TABLE 4. Excavation Methods in Japanese Mines (1868-1932)

Type of deposit	Excavation method	Place of use	Time of first use	Remarks
Vein deposits	Traditional pickaxe method (unsystematic)	All mines before the Meiji period; some small mines at present		The oldest method, still used at present
	Overhand stoping	Presently used at most mines	After 1868	Introduced by foreign engineers at Ikuno and Sado
	Underhand stoping	Presently used in part at most mines Especially Yamagano	After 1868 1918	Used to excavate ore nodules lying beneath tunnels; a supplementary method used with overhead stoping
	Shrinkage method	Hitachi Osarizawa Arakawa Hoshino Kōnomai Taio Sado, Iwami	1905 1915 1916 1920 1925 1928	Now no longer used Standard method at present Still used at present Standard method at present Standard method at present
	Filled rill stoping	Arakawa Yamagano	1924	Used at present Standard method at present
	Filled flat-back stoping	Kushikino		Standard method at present
	Chamber method	Mines with especially wide veins		An old method with many applications; used in a supplementary way
Massive ore deposits	Open-cut method	Used in the vicinity of outcroppings of black mineral deposits at such mines as Kosaka, Kunitomi, Meiji, Abenojō, Taishō, Yoshino, Tōdoya; also used at iron mines (Kamaishi, Sennin, Kutchan, Abuta, etc.) and at the Kamioka lead mines		Traditional method still used in part; begun at Kosaka in 1908
	Overhand stoping	Ofuku	1924	
	Filled chamber method	Kamaishi, Kunitomi, Ashio (for extracting nodules from quartz formations)		At Ashio, replaced the square-set method as the standard method in 1916
	Shrinkage method	Ashio (Liparite nodules)		Presently used for very hard deposits only
		Kamioka		Presently used for very hard deposits only
		Kamaishi	1930	

Type of deposit		Excavation method	Place of use	Time of first use	Remarks
Copper-containing sulphide deposits	Small deposits, metasomatic deposits, and iron deposits	Pillar and room method	Hanaoka		Presently in use (with refilling)
			Yanahara	1920	Presently in use
		Filled diagonal stoping method	Yoshino	1926	
		Filled flat-back stoping	Kosaka		Standard method at present
			Kamioka Iwami	1923	Standard method at present
		Square-set method	Hitachi	1905	No longer in use
			Ashio (for extract-nodules in quartz formations)	1919	No longer in use
		Caving-type chamber method	Various mines		Presently in use
		Sub-level caving method	Takara	1923	Standard method at present
		Undercut caving method	Tsuchihata	1925	Standard method at present
	Gently sloping strata	Overhand stoping	Makimine, etc.		Ordinarily used with refilling
	Steeply sloping strata	Overhand stoping	Suwa, Iimori, Takagoshi, Minawa, Shirataki		Standard method at present, ordinarily used with refilling
		Underhand stoping	Various mines		Presently used only in special cases
		Filled flat-back stoping	Hitachi, Besshi		Standard method at present
		Shrinkage	Hitachi	1907	Discontinued in 1914
			Higashiyama	1914	Not used at present
			Besshi	1920	Presently used as a supplementary method
		Filled diagonal stoping	Hitachi	1920	Standard method at present
	Lump formations	Filled overhead stoping	Kune		Standard method at present
		Shrinkage	Kune	1917	Not presently in use
		Filled flatback stoping leaving rock support pillars	Hitachi		
		Filled diagonal stoping leaving rock support pillars	Hitachi		Used at present; commonly called "cutting-fill method"

Source: Nihon kōgyō hattatsushi [History of the development of Japanese mining], vol. I (1932), pp. 142-145.

Note: The word "presently," as used above, refers to the year 1932.

According to the same government report quoted above:

> . . . an official notice had already been posted to the effect that after the completion of the ore concentration plant the old usages were to be abandoned and that the kanako, etc., were to be transferred to operate there. But, unexpectedly, complaints arose. We saw that if matters were left as they were it would be impossible to change the old ways, and therefore we were resolute in our decision to carry through the reforms. But we are apprehensive that when reforms are made in customs that have existed for hundreds of years, [those opposed to the new system] might for a time cause disturbances aimed at impeding the government operations. Therefore we shall take the precaution of posting beforehand 15 police personnel. When the ore concentration plant is completed on 6 July 1878, the kanako are to be assembled there and made to work at refining the silver. The purchase price for their metal will be increased from 8.6 sen per monme [unit of weight equal to 3.75 grams] to 9.2 sen per monme. . . . Since previously ore was refined at individual houses, a part of the refined silver had been concealed. However, by refining at the ore concentration plant this evil will disappear.

However, it is apparent from later developments at the mines that opposition from yamashi and kanako middlemen continued and that the government tried a conciliatory approach, by raising from time to time the purchase price for refined silver. In June 1879 the purchase price was raised by 0.3 sen and in September it was further raised by 0.5 sen to reach 10 sen per monme. In June of the following year the price was again raised by 0.5 sen.

Then, in April 1881, it was reported that the kanako were demanding an additional price rise of 1 sen. The government at that point hardened its decision to eliminate completely the system of using the kanako as middlemen. 30 June 1881 was set as the date for eliminating the system, until which time silver would be bought at the price of 15 sen per monme, which was somewhat higher than the middlemen had been demanding.[36]

The kanako pleaded for an extension of the deadline, and the government, by granting an extension of one year as a condition for compliance, finally succeeded in bringing the management of all production and related business into its own hands.

After the end of the former managerial system, the former yamashi and kanako tended to be incorporated into on-site supervisory positions as direct government employees. The horidaiku and other mine workers became "wage labourers" and for the first time enjoyed "modern" employment contracts between themselves and the mine managers.

Thus, at the Innai mines, discussed above, the subcontract system which had depended on the former yamashi and kanako was being deliberately dismantled. But this is not to say that all such subcontract systems came to an end during the same years.

In coal mines, a subcontract managerial system known as the naya ("barn") system developed during the Meiji era and lasted until the 1930s, and in certain other non-ferrous mines there flourished so-called hanba subcontract systems. Such systems had the common feature of being based on pseudo-family relationships between "parent and child" or between "older and younger brother," and the Japanese words to designate these differences in social position reflected this way of thinking.

However, the yamashi-kanako subcontract system and the newer types of subcontract systems used in the coal mines and in other non-ferrous mines had different raisons d'être. The former system pervaded almost the whole of production and sales relationships and caused economic activities to tend to be carried out mainly for short-term profits only. However, in many cases, the latter systems were deliberately introduced within a framework of management and labour policies elaborated by mine owner-operators who were well acquainted with effective management theory and techniques.

V. OVERCOMING ANTI-MODERNIZATION IMPULSES

As previously mentioned, the dismantling of the subcontract system built around the yamashi and kanako did not proceed without opposition or impediments.

The setting up of "government-operated mines," the guidance given by foreign employees, and the resultant development of mechanized production systems came as bolts from the blue to the yamashi and kanako who had until then been pursuing [without restriction] their own self-centred economic activities.

The yamashi and kanako tried in various ways to slow down or prevent the modernization process, and often tried to make their subjugated labourers cooperate in such schemes.

With respect to the series of protest actions to be described below in some detail, it is, at the present stage of historical research, impossible to point out any single individual who can be considered the leader of the protest movement. However, it is not unreasonable to see in the protest actions much that reminds us of the Luddite Movement which, in response to the rapid pace of the English Industrial Revolution, broke out at the end of 1811 under the leadership, or at least the widely supposed leadership, of one "Ned Ludd" (who may have been an invented personage since his historical existence is difficult to prove) and which involved the destruction of machinery in the spinning and weaving industries in central and northwest England.

Ikuno Silver Mines

The first appearance of such destructive actions in Japan took place at the Ikuno mines. The government operation of the Ikuno mine complex had its origin in the expropriation of the region's Taisei and Tenju mines, from their former operator, the yamashi Adachi Taemon. The expropriation order was issued in December 1868, and the following year Taemon was forced to "donate" the mines to the government, on grounds that silver ore yields had been small and that their quality had been poor. The mines were immediately declared "government-operated" and the former workers were prohibited from entering the premises.

At the time of this expropriation, the former operator Taemon released from his employ the subordinate refining and metal-producing sub-contractors (kanako) as well as the mine workers. He requested from the government a sum of 7,000 yen to compensate them for their loss of work, but only 1,000 yen was obtained.[37]

With the coming of the adviser Coignet and the mechanization of all aspects of mining and refining, many of the former workers were no longer needed and had no alternative but unemployment. Angry that the government was planning to gain, without their having a share, an unprecedentedly large yearly return as a result of mechanization, they held protest meetings and in their desperation were prepared to resort to terror tactics if they thought it necessary.

In response, the government carried out the following policies:

1. On 26 May 1869 the above-mentioned mines were closed down and blockaded.
2. On June 9 an "audit judge" named Ida Gozō and other officials were sent from Tokyo to reprimand the nine persons seen as the main conspirators.
3. On June 29 the prefectural governor, Komatsu Akira (who was later active in both educational and financial circles), was sent to reprimand the workers.

4. A mass petition from the workers was accepted and for a certain period "relief rice" was granted to each worker — three gō (a little over half a litre) per day.

The petitioners had stated that since Ikuno was a remote and infertile region, there was no way to earn a livelihood except in the mines. They had further stated that without rice grants they would have no means to survive until the autumn harvest, since poverty prevented them from buying rice, whose price was steeply increasing.

However, on 15 October 1871 there was a case of mass violence, in which the mines' head office was set on fire and the government office workers barely managed to escape with the mines' business records. Historians have usually asserted that this was mainly a protest against the dismissal of the former local governor during a time of local government reorganization, or against changes in the land tax. But these are not very realistic motives, and it would be more correct to see the protest as having been directed against the rapid progress of modernization, i.e. against a modernization which meant the mechanization, under the guidance of Coignet and other foreign advisers who followed him, of all sectors of production, especially the refining sector (crushing, milling, roasting, barrel amalgamation).

The government paid out 12,560 yen to repair the damages caused by the fire.

The first stage of modernization at the Ikuno mines under the guidance of Coignet is considered to have been completed in March 1876 with the installation, in the already constructed amalgamation plant, of 32 Freiberg-type amalgamation barrels. Operations using the new machinery began at once. The new production methods hastened the final elimination of the last vestiges of the old yamashi-kanako system [which depended on a decentralized refining sector].

As in all the other mines to be discussed below, the process of eliminating the yamashi-kamako system involved, during its most critical period, the stationing of police personnel. In the case of

the Ikuno mines, nine police personnel were stationed in March 1877 to maintain public order during the decisive period of changeover to the new management and production systems. As the situation later calmed down, the police personnel were reduced in number and finally withdrawn.

Sado Island Gold Mines

In January 1872 labourers and their families, who had been put out of work because of modernization, destroyed iron plates for use in assembling machinery as well as rails for ore-transport carts. There were rumours that foreign advisers would be sought out as targets of violence.

In response, the government sent two platoons of soldiers from Shibata (present-day Niigata) prefecture to guard against further trouble. It later appointed as personal guards for the foreign employees over 100 men of samurai family origin, i.e. from the highest-ranking social class in pre-1868 feudal times, who had formerly served in the Sado administrative office of the Tokugawa central government.

Another method used by the government to quell unrest was the adoption of a proposal for the relief of unemployed labourers which had been made by Suzuki Shigemine, an official of Aikawa prefecture (present-day Sado island, a part of Niigata prefecture). A government bureau to train unemployed labourers to do new types of work (e.g. silk production, leather production, etc.) was set up, and funds were dispensed to help the trainees, in the hope that their lack of productive activity would be only temporary.

Nevertheless, from time to time there were cases of robbery and arson. For example, in 1877 three attendants at the mine's head office were murdered and 4,300 yen in government funds were stolen; in 1881, the newly built gold concentration plant was lost in a fire (presumed at the time to have been caused by arsonists); in 1884 warehouses

containing gold and silver amalgams were destroyed and five pieces of semi-refined gold worth 1,645 yen were stolen; and in the middle of the night on 2 January 1885 fire broke out (possibly due to accident) from a steam boiler used to operate transport machinery inside one of the mines, destroying not only the immediately attached buildings but also a machine shop, the mine office, a metalworking shop, and a coal warehouse.

On Sado island the completion of an important stage in the work of the foreign advisers is considered to have taken place in February 1876 with the end of the old refining methods. By November of the same year, large strides had been made in the opening of new mine tunnels and in the same month the old custom of allowing certain mine tunnels to be rented out, so to speak, to yamashi and kanako was stopped. It is obvious that the reason for stopping this practice was that as long as it existed there was a confused mixture of public and private interests of a kind that was not well suited to modern types of mine management.

The first case of robbery mentioned above broke out just after the decisive period of changeover which did away with the yamashi-kanako system. Fearing a recurrence of such violence, the government in April 1877 stationed a total of nine police personnel at the mines.[38]

Ani Copper Mines

At the Ani mines there were also cases of violence directed against modernization. For example, in 1880 an arsonist set fire to a government warehouse destroying some 1,300 koku (about 6,500 US bushels) of rice which were being stored for consumption at the mines.

This violence is thought to have been in protest against a government reform in March 1877 whereby the old system (which had existed under the pre-1868 Akita han government) of paying kanako middlemen for unrefined ore in the form of rice, salt, firewood, and clothing was

ended and replaced by a system of money payment, namely 32 sen for 10 kanme of ordinary copper ore (96 sen in the case of ore containing a high proportion of gold). This reform was meant as a prelude to the elimination of the yamashi-kanako system, and nine policemen were stationed in the attempt — though not wholly successful, as shown above — to prevent violence.

In 1879, a change to a new mining method was made at the six Ani mines and, as stated before, at the nearby Mukai mine the excavation foreman Reichl (a foreign employee) gave direct training in new mining methods and the repair of old tunnels. Miners who had mastered the modern methods were selected to work at redeveloping the six Ani mines as well as other mines in the region, such as the Daira lead mine.

In an attempt to deter possible trouble from kanako and workers [who might fear unemployment because of the new methods], the number of police personnel, which at one time had been reduced to only two, was increased to ten. They included guards who were especially charged with looking after the safety of the foreign employees.

These measures were successful and the government also succeeded in abolishing the old system of middlemen operators (yamashi and kanako).

Afterwards, in the refining sector, a roasting plant was set up and success was achieved in experiments with a process of "natural calcination" using pyrite ores. The number of police personnel was kept at ten during the installation of a large ore-roasting furnace, a Piltz furnace, and two small furnaces. The number of police personnel was again reduced to two (in May 1882), but only after these installations were completed.[39]

Innai Silver Mines

At the Innai mines, management of all aspects of production from mining through refining remained for some years in the hands of yamashi and

kanako middlemen. But by 1876 the government had adopted the position that the old customs of allowing these middlemen to buy (and then resell) the refined silver should no longer be permitted. However, the government was still groping for a concrete plan for instituting the needed reforms. Just at that time, in 1876, Coignet visited the Innai mines during one of his countrywide inspection tours and related his experience with reforming old practices at the Ikuno mines. Rumours of impending changes spread, and the yamashi and kanako who were benefitting from the old system felt a heightened sense of crisis.

As a precaution against possible threats to public order, the government in March of the following year stationed nine police personnel at the mines.

In the meantime, the government continued to study possible ways of reforming the old system. The yamashi and kanako middlemen continued, as before, to be delegated control over mining and ore concentration (dressing), but it was decided to put the refining process under more effective government control. Silver refining was to be done at a new plant which was completed in July 1878. Immediately after completion of the new plant, some of the kanako and their subordinate labourers were assembled there and put to work in the operation of the new facilities.

In order to ensure that these changes would take place smoothly, the government had in June increased the number of police personnel by 15, and set up at Innai a branch police office. Another government measure aimed at softening opposition was to increase, a little at a time, the purchase price paid to the kanako for refined silver.

The above changes proved a success and the refining plant was increased in size in November of the same year. A short time later the government, with confidence, entirely abolished the former kanako system at the mines as of 30 June 1882. (All kanako who continued to work at the mines and the new refining facilities were thereafter considered to be directly employed by the government.) At the same

time, the number of police personnel at the mines was reduced to ten.

One reason the government was able to effect this change so smoothly was the visit to the mines made by Emperor Meiji in September 1881, during his second official tour of Japan's Tōhoku region (the northern part of the main island of Honshu). During his visit to the Innai mines, the emperor inspected the steady progress of the facilities being installed under the guidance of B. Rossing, and presented a gift of sake to all mine employees, including the ordinary manual workers.

Although ever since his accession to the throne in 1868 Emperor Meiji had made frequent travels throughout the country, it was a rare event for him to visit a mine. Besides the visit to the Innai silver mines in 1880, the only other mines the emperor had visited had been the Handa silver mines in Fukushima prefecture, inspected during his first Tōhoku tour in 1876.

It is interesting to note the historical background of the emperor's visit to the Handa mines.

The Handa mines had in 1873 been designated as "government operated" (see Table 2), but the following year they were sold to the entrepreneur Godai Tomoatsu and began to be redeveloped as a privately operated enterprise.

As a result of the close friendship between Godai Tomoatsu and Coignet (adviser at the government-operated silver mines), operations at Godai's Handa mines had at first depended heavily on the experience of the Ikuno mines. Both new techniques and trained workers were brought to Handa from Ikuno. However, operations using the new methods soon ran into difficulty when residents of nearby villages demanded that the operations be stopped, saying that water which had been released from the mines and the concentration and refining sites was damaging their rice fields.

To overcome the problem, Godai Tomoatsu first built three sedimentation

ponds into which the drained water was introduced and mixed with lime before being released. As a second measure, he requested that analysis of the water and its sediment be made by the mine division of the government's Department of Industries and also by his friend Coignet. According to the former's report, prepared in June 1876 by J.C.H. Godfrey, Chief Government Mining Engineer, the water had a "neutral reaction" and "after having been allowed to deposit all matter held in suspension and thus become perfectly clear cannot exercise any deteriorating influence upon crops."[40]

An an indirect measure to quell local discontent, Godai Tomoatsu organized a visit to Handa by his close friend Ōkubo Toshimichi, who was at the time Interior Minister and was in charge of making preparations for the emperor's forthcoming tour of the Tōhoku region.

When the visit of the emperor was realized, the problem of distrust from the local populace was settled through the emperor's "sublime authority."[41]

Again, in the case of the emperor's visit to the Innai mines in 1881, a deliberate attempt was made to use the emperor's "sublime authority" — this time to quiet unrest which was centred on the refining sector, where large-scale reforms were being planned to do away with the system of inefficient and exploitative control by yamashi and kanako middlemen.

However, in spite of all these efforts to quiet unrest at the Innai mines, a series of violent protests against modernization continued. At 3 a.m. on 12 November 1882 an arsonist destroyed the important concentration ore dressing plant. In March 1883 the forging plant was likewise lost to fire, and in October of that year a troublemaker entered an explosives warehouse and deliberately blew it up.[42] Thus, incidents of violence impeded the smooth progress of modernization at the Innai mines.

It is worthy of note that the process of bringing about the above-

mentioned changes from the traditional management methods to more modern management methods based on mechanized production typically had a close association with deliberate displays of official power and authority in the form of police and soldiers, and even, in the exceptional case, the presence of the emperor.

The fundamental reason behind the opposition to the breakup of the old system was, needless to say, fear of unemployment. But there were no doubt other reasons, too. For example, one report noted that individual families, which had under the old system refined ore in their own homes, would under the new system lose their capacity to "conceal and sell as contraband a part of the refined metal."

We may suppose that the old practice of concealing metal was not limited to the Innai mines alone but was widespread. One bit of evidence is in the form of a petition signed by all workers at a certain section of the Osarizawa copper mines in 1878. In this petition, the workers noted that they had lost work due to the introduction of western-type pulverizers and asked the managers to restore the former working arrangements on condition that they promise not to engage in "contraband sales."[43]

VI. MODERN MINE TECHNOLOGY TAKES ROOT

It was extremely difficult to plan a standardized nationwide adoption of any one of the various technologies introduced by the foreign employees. This was partly due to the variety of nationalities among the foreign employees, and consequently the variety of technologies in which they were most proficient. Moreover, in many cases the introduction of new technologies met with obstructions caused by the traditional yamashi and kanako mine operators who were facing a crisis due to the breakup of the old subcontract system. Very often, indeed, new technologies were destined to undergo repeated experiences of "trial and error."

As an example of such a "trial and error" course, at the Innai silver mines the government in 1877 expropriated the traditional refining sector of production, which had been monopolized by subcontractors using antiquated methods. In its place, the government introduced a refining technology based on electrolytic precipitation. However, in spite of repeated tests, satisfactory results were not obtained. Thus, five years later, this process was abandoned and the equipment and refining plant were replaced by the Augustin process which had earlier been adopted by Ōshima Takatō at the Kosaka mines.[44] A long time was required, however, before the new process was fully operational, and in the meantime it was necessary to revert to the use of the traditional methods of refining.

The government became keenly aware of the need to set up an educational system which would help students attain a correct understanding of the guidance being given by the foreign employees and which would enable them to contribute to firmly establishing in actual practice the

content of this guidance. Such education should impart knowledge of mining theory and technology in a systematic way.

Already before the start of the reformist Meiji government in 1868 there had existed a small mining school in Hakodate (see p. 6). After 1868 there had been other such efforts such as the small mining school set up by Coignet at the Ikuno mines, and the systematic on-site training in various aspects of mining given at the Mukai mine by Reichl, at the suggestion of the visiting engineer Mezger. However, none of these training courses was directly operated by the government and none continued for very long. Those who received training in these courses came to understand the foreign employees' guidance and played important, if often supplementary, roles in the process of firmly establishing the new methods. Unlike the university graduates to be mentioned later, however, in most cases little is known of their later activities.

On the recommendation of Ōshima Takatō, a graduate of Pumpelly and Blake's training course at Hakodate who was one of those Japanese best acquainted with modern mining theory and practice, the government in 1871 established within the Ministry of Industries a special section (called Kōgakuryō) which was in charge of education for mining and other fields of technology.[45] In 1877 the name was changed to Kōbu Daigakkō ("engineering college"). Most of the instructors, as well as the "principal," Henry Dyer, were brought from England.[46] (See Table 5.)

It should be noted, however, that the content of the education given in the above government institution included, according to Dyer's own plan, some of the strong points of the mining and engineering education of Germany and France, together with the strong points of such education in England.[47] In the process of Japan's modernization, this Kōbu Daigakkō had an extremely important role in imparting and diffusing, in a systematic way, modern (as of a hundred years ago) theory and practices not only of mining engineering but of engineering as a whole.

TABLE 5. Foreign Employees at the Kōbu Daigakkō (Training School of the Ministry of Industries)

Country of origin	Surname	Job description	Monthly salary (yen)	Beginning of contract	End of contract (remarks)
England	Dyer	Principal, and instructor in geometry and civil engineering	660	1873	1882
	Divers	Instructor in chemistry and (after 1882) principal	500	1873	1885 (trans. to Min. of Education)
	Ayrton	Instructor in physics and electrical communications	500	1873	1878
	Milne	Instructor in geology and mining	350	1876	1885 (trans. to Min. of Education)
	Marshall	Instructor in physics	350	1873	1881
	Brinkley	Instructor in mathematics	350	1878	1880
	Conder	Instructor in architecture	350	1877	1882 (trans. to Building and Repairs Bureau)
	Alexander	Instructor in civil engineering	350	1879	1885 (trans. to Min. of Education)
	Thomson	Assistant instructor in surveying and civil engineering	234	1878	1881
	Perry	Assistant instructor in civil engineering	333	1875	1879
	West	Instructor in machine sciences	350	1882	1885 (trans. to Min. of Education)
	Angus	Assistant instructor in machine sciences	234	1878	1881
	Cauley	Assistant instructor in machine sciences	200	1873	1878
	Dixon (James M.)	Instructor in English	300	1880	1885 (trans. to Min. of Education)
	Dixon (William G.)	Instructor in English	250	1876	1879
	Craigie	Instructor in English	208	1873	1876
	Brindley	Instructor in mining technology and head supervisor of miners	230	1875	1881 (trans. to Construction Bureau)
	Gray	Instructor in electrical communications	234	1878	1881
	Mondy	Instructor of drawing	208	1873	1877
	Barr	Assistant instructor of drawing	234	1878	1881
	Clark	Drawing assistant	150	1873	1878
	King	Constructor of models	141	1873	1875
	Jones	Instructor in surveying and preparatory school teacher	250	1873	1878
	Hamilton	Preparatory school teacher (teaching pupils aged 13-17)	250	1874	1877

	Sandeman	Preparatory school teacher (teaching pupils aged 13-17)	130	1874	1874
	George	Preparatory school teacher (teaching pupils aged 13-17)	130	1874	1874
	Langden	Preparatory school teacher (teaching pupils aged 13-17)	130	1874	1877
	MacLay	Preparatory school teacher (teaching pupils aged 13-17)	130	1875	1877
Italy	San Giovanni	Instructor in drawing	300	1880	1883
	Frecci	Instructor in drawing	278	1878	1880
	Fontanesi	Instructor in drawing	278	1876	1878
	Peroglio	Instructor in drawing and modelling	100	1880	1880
	Cappelletti	Instructor in fine arts preparatory course	278	1876	1879 (trans. to Building and Repairs Bureau)
	Ragusa	Instructor in sculpture	278	1876	1882
	Gaillardi	Sculptor	150	1879	1880
England	Marks	Building expert	125	1872	
	Anderson	Building expert	100	1872	1874 (trans. to Construction Bureau)
	Warden	Building expert	100	1873	1874 (trans. to Construction Bureau)
	MacVean	Chief of surveyors	350	1871	1874 (trans. to Construction Bureau)
	Joyner	Assistant chief of surveyors	250	1871	1874 (trans. to Construction Bureau)
	Hardy	Surveying assistant	400	1872	1874 (trans. to Construction Bureau)
	McArthur	Surveying assistant	250	1872	1874 (trans. to Min. of Foreign Affairs)
	Grayson	Surveying assistant	300	1872	1874 (trans. to Min. of Foreign Affairs)
	Cheeseman	Surveying assistant	250	1872	1874 (trans. to Min. of Foreign Affairs)
	Stewart	Surveying assistant	230	1872	1874 (trans. to Min. of Foreign Affairs)
	Wilson	Surveying assistant	250	1873	1874 (trans. to Min. of Foreign Affairs)
France	De Boinville	Architect	300	1872	1874 (trans. to the main office of the Ministry)
England	Eaton	Instructor in general education	200	1873	1873
	Cruickshank	Recording officer	150	1873	1874 (trans. to Min. of Interior)

Sources: Kyū Kōbu Daigakkō shiryō (supplement), pp. 353-356.
Unesco Higashi Ajia Bunka Kenkyu Center, ed., Shiryō: Oyatoi gaikokujin (1975).

Note: Because names in Japanese sources were not usually recorded in the Roman alphabet, in some cases it is difficult to know the original spellings with certainty. The author has relied on the spellings, when available, which are given in the second of the above-mentioned source materials.

In the seven years between 1879, the year of the Kōbu Daigakkō's first graduating class, and 1886, when the above school merged with a part of Tokyo University's "department of sciences" to form the engineering college within the Imperial University (established under that name in the latter year), there were 206 graduates, of whom 48 specialized in mining and five specialized in metallurgy (see Table 6).

The government, as part of its plan to have some of these graduates replace the foreign instructors at the Kōbu Daigakkō (and, later, the Imperial University), selected 11 outstanding graduates and sent them to England for further study. Kondō Obana and Kurimoto studied at the prestigious Royal School of Mines in London, and Kurimoto further pursued his studies in Freiberg, Germany.

One reason the government wished to replace the foreign instructors in Japan with Japanese was economic. In 1879, the number of persons from abroad who were employed by the Ministry of Industries was less than half the peak figure of around 300 in 1874, but their salaries nevertheless consumed a very large portion (66 per cent) of the Ministry's ordinary budget.[48]

During the period of the existence of the Kōbu Daigakkō (1879-1886) there was another high-level educational institution which was similarly concerned with engineering technology. This was the "sciences department" (rigakubu), mentioned above, of Japan's only government university at the time, namely Tokyo University (renamed Imperial University in 1886). The "sciences department" included a section giving instruction in mining and metallurgy. Graduates from this section tended to enter such professions as teaching and mine administration, while graduates of the Kōbu Daigakkō (the university-level engineering school within the Ministry of Industries) tended to exercise important roles in replacing the foreign employees in giving on-site training in modern mining technologies, thus ensuring continued guidance so that the new technologies would firmly take root in Japan.

Table 7 indicates the development of university-level government-

TABLE 6. Graduates of the Kōbu Daigakkō (1879-1885)

Year of graduation	Graduating class	Graduates from the mining course	(Sub-total)	Graduates from the metallurgy course	(Sub-total)
1879 (Nov.)	1	Kondō Takazō Asao Masaki	2	Obana Tōkichi Kurimoto Ren	2
1880 (May)	2	Oki Tatsuo Kurihara Sei Maki Sōshin Yoshihara Masamichi Koga Tōka Matsushita Chikanari Sengoku Ryō Kozaki Tominori Yamada Kin'ichi Kondō Kikuzaburō Arakawa Sadaji	11	Takashima Yonehachi	1
1881 (May)	3	Fujino Itsuzō Harifusa Takeshi Sugata Shigeru Sera Teizō Tsuno Toyonoshin Hayashi Raijirō Ishibashi Seishin Nagai Hisatarō Satō Tōru	9	Nobe Shichirō	1
1882 (May)	4	Miyazaki Kakichi Matoba Ataru Ishida Osamu Kanda Reiji Mita Shuichi Ōshima Rokurō Kosugi Tetsusaburō Harubara Waijirō	8	Kitamura Kenji	1
1883 (May)	5	Yamagata Sōichi Fujioka Sakujirō Suzuki Rokunosuke Matsuda Eiichi	4		0
1884 (May)	6	Ōhara Junnosuke Ōtsubo Ichirō Saitō Seiichi Shimada Kenroku Mamiya Igajirō Abe Masayoshi Hidaka Itarō Kayahara Washitarō Murase Shirō (formerly Yamaguchi)	9		0
1885 (May)	7	Kawai Yasushirō Kuroda Kiyoteru Nakamura Takeji Ishizaka Kin'ichirō (formerly Mizuno) Akiyama Chōmei	5		0
Totals			48		5

Source: Kyū Kōbu Daigakkō shiryo (supplement), pp. 349-352.

Note: The above list omits graduates in courses other than mining and metallurgy.

TABLE 7. High-level Institutions Giving Training in Mining and Metallurgy during the Meiji Era (1868-1912)

Name of institution	Date of foundation	Date of establishment of course/ faculty	Name of faculty	No. of years of training	No. of graduates trained in mining and metallurgy (up to 1912)	Remarks
Tokyo Daigaku [Tokyo University]	Aug. 1877	Aug. 1877	Mining & Metallurgy Dept., Faculty of Sciences		16 (B.Sc.)	First graduates in Feb. 1879
Kōbu Daigakkō [Engineering Coll.]	11 Jan. 1877	11 Jan. 1877	Mining Dept. and Metallurgy Dept.			First graduates in Nov. 1879
Tokyo Daigaku			Mining & Metallurgy Dept., Faculty of Industrial Arts			Separated from Faculty of Sciences in Dec. 1884
Teikoku Daigaku [Imperial University]	1 Mar. 1886	1 Mar. 1886	Mining & Metallurgy Dept., Faculty of Engineering	3		Continued courses formerly offered at Tokyo Daigakku and Kōbu Daigakkō
Tokyo Teikoku Daigaku [Tokyo Imperial University]	Changed name in June 1898	June 1898	Mining & Metallurgy Dept., Faculty of Engineering	3	279	Formerly Teikōku Daigakku; the number of graduates include graduates from Tokyo Daigakku, Kōbu Daigakkō, Teikōku Daigakku and Tokyo Teikōku Daigakku
Tokyo Teikoku Daigaku	June 1909		Separated into Mining Dept. and Metallurgy Dept.		61 (mining) 15 (metallurgy)	
Kyoto Teikoku Daigaku [Kyoto Imperial University]	June 1897	1899	Mining & Metallurgy Dept., Faculty of Sciences & Engineering	3	100	
Kyushu Teikoku Daigaku [Kyushu Imperial University]	Sep. 1911	Sep. 1911	Mining Dept. and Metallurgy Dept., Faculty of Sciences			
Engineering Dept., Daisan Kōtōgakkō [Third National Higher School]	Sep. 1896	Sep. 1896	Mining & Metallurgy Division	4	11	Closed after graduating class in 1900
Osaka Kōgyōgakkō [Osaka Industrial School]	Oct. 1896	May 1897 (mining)	Metallurgy Division	4	32 (metallurgy)	Accepted students who had completed 4 years of higher elementary school education

Osaka Kōgyōgakkō	Upgraded in 1899		Metallurgy Division	3	115 (mining)	Accepted middle school graduates
Osaka Kōtō Kōgyōgakkō [Osaka Higher Industrial School]	Changed name in May 1906	May 1906	Mining & Metallurgy Division	3		Formerly Osaka Kōgyōgakkō
Kumamoto Kōtō Kōgyōgakkō [Kumamoto Higher Ind. School]	1906	1906	Mining & Metallurgy Division	3	105	
Sendai Kōtō Kōgyō-gakkō [Sendai Higher Industrial School]	Apr. 1907	Apr. 1907	Mining & Metallurgy Division	3	152 (mining) 77 (metallurgy)	
Akita Kōzan Senmon Gakkō [Akita Mining School]	Apr. 1911	Apr. 1911	Mining Division and Metallurgy Division	3		
Meiji Senmon Gakkō [Meiji Special School]	15 Apr. 1909	15 Apr. 1909	Mining Division and Metallurgy Division	4		
Akaike Kōzan Gakkō [Akaike Mining School]	1902	1902	Mining Division	2	26	Closed in Nov. 1902
Faculty of Sciences & Engineering, Waseda Daigaku [Waseda University]	Feb. 1908	Apr. 1909	Mining Dept. and Metallurgy Dept.	4		First graduates in 1913

Sources: Meiji kōgyōshi, kōgyō-hen, pp. 960-961; and Nihon kagaku gijutsushi taikei, vol. 20 (saikō yakin gijutsu-hen), p. 175.

sponsored education in mining and metallurgy, starting with the two above-mentioned institutions (which merged in 1886) and continuing with the establishment of a number of other similar courses in various regions.

We must also mention the various apprentice-students (minaraisei) who were sent by the Ministry of Industries to act as assistants to the foreign employees in the years before the first graduating classes of the university-level courses. These student-apprentices, who underwent many hardships, deserve recognition for their early role in introducing machine technologies.

The purpose of this early system of student-apprentices was to meet the urgent need for trained personnel well acquainted with the types of industries under the Ministry's supervision, i.e. industries which typically made use of technologies that were quite new to Japan.[49] The first of these student-apprentices began their training in 1873.

One of these student-apprentices was Abe Tomokiyo from the former Nanbu han (present-day Iwate prefecture in northern Honshu). He left behind an autobiography entitled Kijiroku which, although omitting much desired detail about the trainees' curriculum, informs us that he received direct instruction from J.C.H. Godfrey, the Ministry's chief mining engineer, and that beginning in November 1873 he accompanied Netto, the German engineer put in charge of technological innovations at the Kosaka silver mines. Until Netto left the Kosaka mines four years later, Abe worked at putting into practical operation the Ziervogel precipitation method (a "wet-type" refining process) and the Hunt-Douglas copper-separation method, both of which were introduced by Netto.

Abe writes that while these were the first applications of these new technologies in Japan, only one textbook (published in the United States) was available to him. He states that the difficulties in planning for the adoption of the new methods were virtually "beyond description." He reports that the adoption of the new refining methods

brought with it the breakup of the traditional yamashi-kanako sub-contract system, together with a good deal of resentment throughout the Kosaka mining district. Nevertheless, he goes on to describe vividly how he and the other innovators, led by chief engineer Netto, persisted in their work, believing single-mindedly in its eventual success.[50]

It is important to appreciate the basic foundation of the process, throughout Japan, by which mining and metallurgy specialists who graduated from the Kōbu Daigakkō and from Tokyo University eventually replaced the foreign employees in mine administration, the teaching of scientific and engineering principles, and the on-site introduction of modern and high-level mining technologies. It may justifiably be said that a large part of this "foundation" was laid by people whose names have only recently become known or who even yet remain anonymous. These foundation-builders include the trainees at Coignet's school at the Ikuno mines, the trainees in the course given at the Mukai mine by foreman Reichl (with advice from Mezger), and the early student-apprentices, including Abe, who were sent out by the Ministry of Industries.

Following such early training experiments, there grew up not only these high-level training courses, but also the elementary-level training courses given at the institutions listed in Table 8.

Largely for financial reasons, the government in 1880 announced a set of general rules for selling to non-government entrepreneurs the industrial enterprises which had during the previous decade been developed at government expense. The mining industry was no exception.

The government's mine assets were sold at various times (see Table 2), and the period of government ownership and operation of mines came to an end in 1896 with the sales of the Ikuno and Sado mines. The purchasers of the mines were usually large firms with political affiliations, such as Mitsubishi, Mitsui, Furukawa, or Fujita.

While the ownership and operation of mines was being transferred to private entrepreneurs (subject to certain government regulations), high-level training in mining engineering and metallurgy remained a government responsibility.

By 1885, a number of graduates from government-sponsored university-level courses were already working in major mines throughout Japan, especially in the Ani and Innai mines which were sold to Furukawa interests in that year. Although historical references are probably incomplete, we may state that at least the following graduates were

TABLE 8. Institutions for Training in Elementary-level Mining Technology

Name of school	Brief description
Kōshu Gakkō	Opened in Tokyo in 1888; incorporated in 1898; name changed to Kōgakuin in 1928; four-year course of study.
Sado Kōzan Gakkō	Opened at the Sado mines in 1890; preparatory course of three years followed by a one-year specialization course; the latter course divided into four departments, viz., mining, metallurgy, instrumentation, and architecture; also training in first-aid measures to care for injured persons; three hours of course work at night following practical work experience during the day; graduates obligated to work for three years at the Sado mines; first graduating class of seven persons in 1891; school closed after sixth graduating class.
Fukuoka Kenritsu Kōgyō Gakkō	Opened by Fukuoka prefecture (Kyushu) in 1896; a separate mining course set up in 1901 with monetary contributions from the Chikuhō coal mining cooperative; four-year course of studies.
Mitsui Kōgyō Gakkō	Opened at the Miike mines, Ōmuta city, Fukuoka prefecture, in 1907; a mining course set up the next year; three-year course of studies.
Waseda Kōshu Gakkō	Mining and metallurgy department opened in 1907; attached to Waseda University in Tokyo.
Hokkaidō Chōritsu Sapporo Kōgyō Gakkō	Opened in Sapporo (Hokkaido) in 1917; originally called the Sapporo Kōgei Gakkō, the name being changed in 1920; three-year course open to students having finished two years of upper elementary education.
Ghikuhō Kōzan Gakkō	Opened at the Chikuhō mines (northern Kyushu) in 1919; a general course of four years followed by a high-level course of three years; open to students having completed upper elementary education.
Yūbari Kōgyō Gakkō	Opened at the Yūbari mines in Hokkaidō in 1920; operated by the Hokkaidō Tankō Kisen Kaisha (a coal mining and shipping company); a three-year course of studies.

Sources: Kōzan Konwakai, ed., Nihon kōgyō hattenshi, vol. 1, p. 78; Sado kinginzan shiwa, pp. 483-484; Nihon kagaku gijutsushi taikei, vol. 20 (Kōzan yakin gijutsu-hen), p. 176.

working at mines in 1885.

Ani Mines	Kondō Rikuzaburō	(2nd graduating class of Kōbu Daigakkō = "KD")
	Kitsunezaki Tominori	(2nd class of KD)
	Ishida Osamu	(4th class of KD)
Innai Mines	Matsushita Chikanari	(2nd class of KD)
	Maki Sōshin	(2nd class of KD)
	Shimada Kenroku	(6th class of KD)
Kosaka Mines	Sengoku Ryō	(2nd class of KD)
Sado Mines	Kanda Reiji	(4th class of KD)
	Watanabe Wataru	(Tokyo Daigakku)
Ashio Mines	Oki Tatsuo	(2nd class of KD)
Hitachi Mines	Kanda Reiji	(4th class of KD)
Kamioka Mines	Kurimoto Ren	(1st class of KD)
Yoshioka Mines	Hasegawa Yoshinosuke	(graduate of the Daigaku Nankō, one of the government schools which were combined in 1877 to form Tokyo Daigaku)
Ikuno Mines	Wada Tsunashirō	(graduate of the Kaiseijo school operated during the last years of the Tokugawa government; its name was changed to Daigaku Nankō by the Meiji government)
Besshi Mines	Shiono Monnosuke	

As indicated in the above list, most of those persons who actually went to the local mine sites and received direct guidance from the foreign employees were graduates of the Kōbu Daigakkō.

The graduates of the above schools eventually came to be in control of all aspects of production, in the capacity of company section heads in charge of mine engineering, administration, and metal refining. The fact that they were able to continue to promote a type of management based on definite and systematic production plans was a characteristic of the modern type of mining operations begun by the foreign employees.

The modern types of operations were, as previously noted, based on systematic management concepts elaborated by the modern mine operators who replaced the traditional yamashi and kanako. These new concepts permitted and encouraged Japanese workers and managers to learn the theory and practice of advanced skills and management procedures.

NOTES

1. Regarding the Sado mines, see "Kingin gensan ni tsuki, kyokuryoku sanshutsu zōka o torihakarau beki koto" [The need for responding to gold and silver production decline with the utmost efforts to increase yields], a government ordinance prepared in May 1865; also Sado-gun Kyōikukai, ed., Sado nendaiki zokushū [Sado chronological record, additional compilation], vol. 3, 1938, p. 2. Regarding the Ikuno mines, the yamashi Tahei reported to the government administrative office in May 1864 that "the rock tends to be hard and [work] is not proceeding quickly." Yamashi Seishichi reported in September 1866 that "although up to the present season profits have been obtained, [now] there is not any ore production." See Ikuno Machiyakuba, ed., Ikuno-shi [History of Ikuno], volume on mining, 1962, pp. 52-53.

2. Kadoya Yōan diary (unpublished), Akita Prefectural Museum.

3. In Japan, exploitable ore deposits were traditionally designated by such terms as ōnaori, ochiainaori, and otoshi, depending on size, shape, etc. See Chigaku jiten [Dictionary of physical geography], Heibonsha, 1970, p. 943.

4. Kabushiki Kaisha Sumitomo Honsha, ed., Besshi kaikō nihyakugojūnen shiwa [History of 250 years of mining at Besshi], 1941, pp. 168-169.

5. Mitsu Kinzoku Kōgyō Kabushiki Kaisha, ed., Kamioka kōzanshi [History of the Kamioka mines], 1970, p. 693. Mine passageways, or kase, were of various shapes and there were no nationwide standards. For example, the main passageways of the Iwami silver mines measured 6 shaku in height by 5 shaku in width, and were thus called goroku no kase, the first word meaning "five-six." Other mines might have other standards, such as gosan ("five-three") no kase, or even smaller yonni ("four-two") no kase. One shaku equals approximately 30 cm.

6. Corroboration of the view that mine workers were often seen as existing outside the accepted social classes is given in: a) "Innai ginzanki" [Description of Innai silver mine], in vol. 10 of Nihon shomin seikatsu shiryō shūsei, San'ichi Shobō, 1970, p. 507; b) "Besshi dōzan kōjō-oboe" [An oral account of the Besshi copper mines], recording a description given by yamashi Izumiya Kichiemon, kept at the Sumitomo Shūshishitsu; c) an unpublished memorandum by Kawaguchi Tomijūrō addressed in 1789 to "the inspection officer dispatched to the Osarizawa copper mines," kept

in the Kawaguchi family library; and (d) a diary of Kawaji Kiyoakira describing his life and duties at the Sado magistrate's office (bugyōsho) of the Tokugawa government, published under the title Shimane no susami — Sado bugyō zaikin nikki (with annotations by Kawada Sadao), Heibonsha, 1973, p. 141.

7. "Bakumatsu gaikō monjo yakukō" [Translations of diplomatic documents of the end of the Tokugawa period], vol. 20 of Fukuzawa Yukichi zenshū [Complete works of Fukuzawa Yukichi], Iwanami Shoten, 1958, pp. 491, 499, 500, 506.

8. Unesco Centre for East Asian Cultural Studies, ed., Shiryō oyatoi gaikokujin [Materials on foreign government employees (in Meiji Japan)], Shōgakkan, 1975, p. 172.

9. Ōshima Shinzō, ed., Ōshima Takatō Yukizane [The achievements of Ōshima Takatō], 1938, pp. 462-465. Among the students at the Kōshi Gakkō were the Chōshū (present-day Yamaguchi prefecture) samurai Yamao Yōzō and Inoue Masaru. After the Meiji restoration of 1868, Yamao Yōzō helped establish the Ministry of Industries and the Kōbu Daigakkō [engineering college]. Through his lifelong work in mining administration he played a very large role in Japan's industrial modernization during the Meiji period and came to be called "the father of Japanese engineering."

10. In a letter of 21 March 1863 which Blake sent from Shanghai (on his way home) to Muragaki Awaji-no-kami, bugyō (magistrate appointed by the Tokugawa government) in Hakodate, he wrote: "I should like to state to you my opinion that you should send students to America in order that they might see my country's mining equipment and improved weaponry. These students should come to me, and at such time I will provide them with guidance and will instruct them in all matters concerning my country's mines and ships. I hope you would send Messrs. Takeda, Miyagawa, Ōshima, and others. Those named are talented and good students." (Retranslation into English from the Japanese in Fukuzawa Yukichi, "Bakumatsu gaikō bunsho yakukō," pp. 569-570.) Also see Ōhashi Shūji, Bakumatsu Meiji seitetsushi [History of ironmaking in the Meiji and late Tokugawa periods], Agune Publishing Co., 1 July 1975, p. 180.

11. Ōuchi Hyōe and Tsuchiya Takao, ed., Meiji zenki zaisei keizai shiryō shūsei [Collection of materials on early Meiji finance and economy], vol. 17, Kaizosha, 1931-36; also, Kōbushō enkaku hōkoku [Report on development of Ministry of Industries], pp. 91-96.

12. Microfilm No. A-4008, in Ōkuma Shigenobu collection, Waseda University Library.

13. Inoue-kō denki hensankai, ed., Seigai Inoue-kō den [Biography of Inoue Kaoru], vol. 2, Hara Shobō, 1968, pp. 468-469.

14. F. Coignet, "Note sur la richesse minérale du Japon" (translated into Japanese by Ishikawa Junkichi, Haneda Shoten, 1944).

15. Ibid., p. 50.

16. Ibid., p. 105.

17. Nihon kagaku koten zensho [Comprehensive collection of classic writings on Japanese science], vol. 9, Asahi Shimbunsha, 1942, pp. 137 and 144.

18. Coignet's report on the Ani mines was written in 1876. A Japanese translation is kept in the Resources Engineering Departmental Library at Kyushu University. For other details, see Yoshiki Fumio, "F. Coignet to A. Mezger no kindaika kōsō ni tsuite" [On Coignet's and Mezger's ideas regarding modernization], based on an analysis of their reports of visits to the Ani mines. It is contained in the bulletin entitled Zenkoku Chika-shigen-kankeigaku Kyōkai Gōdō Shūki Taikai Bunka Kenkyūkai Shiryō [J-6], [Research reports on the history of mining], 1978, published by the Mining and Metallurgical Institute of Japan.

19. Kabushiki Kaisha Sumitomo Honsha, Besshi kaikō 250-nen shiwa, 1941, pp. 309-311.

20. The Japanese translation of Netto's book was published by Tokyo University in 1880. Refer especially to pp. 54-55. The official government publication Kōbushō enkaku hōkoku (pp. 96-149) also testifies to the fact that modernization began in the refining sector.

21. Yajima Suketoshi, "Coignet monjo ni tsuite — Kōzan gishi Coignet to Ogier no shinshiryō" [New materials on the mining engineers Coignet and Ogier], Unesco Centre for East Asian Cultural Studies, December 1970, pp. 6 and 93.

22. Jean Gimpell, La Révolution industrielle du moyen age; see Japanese translation by Sakamoto Kenzō (1978), pp. 48-54.

23. See Ishikawa Junkichi, tr. of Coignet, "Note sur la richesse minérale du Japon," pp. 3 and 22-23; also see Kōbushō enkaku hōkoku, p. 102.

24. Nihon Keieishi Kenkyūjo, ed., Godai Tomoatsu denki shiryō [Biographical materials on Godai Tomoatsu], vol. 3, Tōyō Keizai Shinpōsha, 1972, p. 111; also see Matsuura Kenji, ed., "Handa ginzan kōgyō enkakushi" [History of mining at the Handa silver mines], written in 1887 and available on microfilm (R28-45-961) at the Osaka Chamber of Commerce Library.

25. Godai Tomoatsu denki shiryō, vol. 3, p. 106.

26. Dōwa Kōgyō Kabushiki Kaisha, Nanajūnen no kaiko [Looking back over 70 years], 1956, p. 24 and 31-32.

27. One example may be seen in "Coignet monjo ni tsuite . . ." (p. 35), in a letter of 20 June 1879 sent to Coignet from Ogier in Tokyo, in which it is stated that "The manual workers from Satsuma are all excellent. However, once they gain some position of authority, no matter how low, they do not obey orders, and there is not one among such persons in some position of authority who does not appear to be trying to paralyse the attempts at improvements that have been so laboriously made. The supervisor Jiro is a good person and works without giving rise to

problems, but the officials who assist him, who are too many, have a clear antipathy for European ways."

28. Kōbushō enkaku hōkoku, p. 102.

29. Ōta Toraichi, Ikuno-shi [History of Ikuno], 1962, pp. 64-67.

30. Kōbushō enkaku hōkoku, p. 122.

31. Besshi kaikō 25-nen shiwa, pp. 278-279 and 298-299.

32. Kitsunezaki Tominori, "Ani kōzan shinkōji no gaikyō" [Conditions of the new work at the Ani mines], in vol. 5 of Kōgaku sōshi [Collection of materials on engineering history housed at the National Diet Library], pp. 230-231. The Kōbushō enkaku hōkoku, p. 124, also points out the need to refine discarded ore at the Ani mines, where the ore selection process had been far from thorough.

33. According to A. Mezger, "Einiges über Bergbau und Hüttenwesen in Japan," as a result of the training of mine foremen at the Mukai training centre, production at the Daira lead mine, 60 km away, increased threefold. He states that these good results were because of strong efforts directed to the following three points: 1) the roles for which the foremen were trained; 2) improving the productivity of all mine workers; 3) more care given to the ore-concentration process. According to Mezger's report on the Ani mines in particular, and also to the Kōbushō enkaku hōkoku, pre-requisites for modern mining were 1) opening horizontal tunnels with tracks for ore carts; 2) opening vertical shafts with machinery installed to facilitate the lifting of ore; 3) the use of chemical explosives (later, dynamite); 4) installation of water drainage tunnels. A fifth important means of overcoming the traditional methods of hand-excavation was guidance in the introduction of rock-cutting machines.

34. Kōbushō enkaku hōkoku, p. 125.

35. In 1879 the Ani copper mines consisted of six subdivisions bearing such names as Ozawa, Makizawa, Sanmai, Ichinomata, and Kayakusa. Mezger referred to each of these as a separate mine site.

36. Kōbushō enkaku hōkoku, pp. 129-131.

37. Ikuno-shi, pp. 70-73. Related materials are Okuganaya-machi goyō-dome; Ōta Toraichi, Ikuno kōzan keikyō (1962); Ishikawa nikki [A diary from the Meiji period]; and the aforementioned Kōbushō enkaku hōkoku, vol. 17, pp. 101-103.

38. Kōbushō enkaku hōkoku, pp. 97-99. See also Sado-gun Kyōikukai, ed., Sado nendaiki tōshū, vol. 9, 1940, pp. 22-27. For data with regard to aid to workers, see Fumoto Saburō, Sado kinginzan shiwa (published by Sado-gun Kyōikukai, 1938), and Mitsubishi kōgyō shashi [A history of the Mitsubishi mining company], published in 1976 by Mitsubishi Kōgyō Semento Kabushiki Kaisha.

39. Kōbushō enkaku hōkoku, pp. 122-125. See also Matsukawa Shichizō, Aniaimachi kyōdoshi, Shūhoku Shinbunsha, 1936.

40. A microfilm of the original document is housed in the collection of materials relating to Coignet and Godai Tomoatsu in the Osaka Chamber of Commerce Library. (Microfilm No. R28-36-952.)

41. Refer to Godai Tomoatsu denki shiryō, vol. 3, pp. 143-147; also Yoshiki Fumio, "1876-nen Fukushima-ken Handa ginzan ni okeru senkō dakusui no shori o megutte" [On the handling of polluted water from washing ore at the Handa silver mines in 1876], a study based on Coignet's and Godfrey's reports, published by the Japan Mining Association in its 1978-nendo Nihon Kōgyōkai Kenkyū Gyōseki Happyō Kōenkai kōen yōshishū.

42. Kōbushō enkaku hōkoku, pp. 129-131.

43. See Kazuno-shi Kyōiku Iinkai, ed., "Osarizawa kōzan kankei monjo" [Documents related to the Osarizawa mines], 1978, pp. 60-61.

44. Kōbushō enkaku hōkoku, p. 131.

45. See Ōshima Takatō kōjitsu (a biography published in 1938), pp. 683-686 for text of Ōshima's proposal (25 September 1870) for the establishment of the Kōgakuryō.

46. Kyū Kōbu Daigakkō Shiryō Hensankai, ed., Kyū Kōbu Daigakkō shiryō-dō furoko, 1978, pp. 353-356.

47. Ibid., pp. 113-116.

48. Nihon Kagakushi Gakkai, ed., Nihon kagaku gijitsushi taikei [Compendium of Japanese scientific and technical history], vol. 8 (on education), 1964, p. 339.

49. Kyū Kōbu Daigakkō shiryō-dō furoko, p. 11.

50. See Research Reports on the History of Mining [J-6], Mining and Metallurgical Institute of Japan (MMIJ), 1978. For a discussion of Abe Tomokiyo's autobiography, see Haga Namio, ed., Oyatoi gaikokujin o sasaetā hito-bito [Persons who helped the foreign employees], which is publication [J-7] of the same Research Report series, MMIJ, 1978.