The Dutch Commitment in its Search for Asian Mineral Resources and the Introduction of Geological Sciences as a Consequence

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1. Outline and Objectives

In the context of European expansion, the Dutch cultivated their interest in Asian metals as major intermediate traders in the South East Asian seas. Among others, Japanese silver and copper were the most lucrative commodities for them.[1] An economic historian, Kawakatsu Heita, recently shed new light on the issue that Japanese metal production and subsequent monetization facilitated a take-off in the Japanese economy comparable to the emergence of modern capitalism in Europe.[2] Kawakatsu cites Hayami Akira's argument that an "Industrious Revolution" occurred in the Edo period, which was comparable to the "Industrial Revolution" in Europe. Kawakatsu further specifies this with reference to Schumpeter's theoretical framework that the control over monetary circulation was the key factor in the outgrowth from the so-called "Asiatic mode of production". In his argument on negative aspects of governmental trade restrictions, the idea of the so-called *Sakoku*

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1 H. Glamann *The Dutch Asiatic Trade 1620-1740* (1958).
H. Furber *Rival Empires of Trade in the Orient 1600-1800* (1976).
Also see J. Obata *Nihon Kôzanshi no Kenkyû* and N. Imai, presentation given at January 26, 1991, on the occasion of Sumitomo Dôfukijo Kenkyûkai.
So far, a concealed reference to the negotiation of price of copper by I. Titsingh has been found in the following works:
F. Luquin *The Private Correspondence of Issac Titsingh, 1, 1785-1811* (1990).
F. Kurihara 'A Japanese Translation of a "Secret Diary" written by Issac Titsingh', in *Keizai to Shakai* 19 (1991) 1-28.
Idem, 'Issac Titsingh's Nagasaki Shokan no Himitsu Nikki 1782-1783', in *Tokyo Joshi Daigaku Shakaigakukai Kiyô* 20 (1992) 1-40.

2 H. Kawakatsu 'Nihon no Kôgyôka wo meguru Gaiatsu to Ajiakan Kyôsô', in *Ajia Kôekiken to Nihon Kôgyôka* (1991) 157-193.

policy as a confinement was discarded. Instead, a positive function of *Sakoku* was emphasized: restrictions necessitated the substitution of imported commodities. This functioned as an incentive for the growth of endogenous industries, and is considered to have caused the "Industrious Revolution" in Japan.[3] Kawakatsu rejects the conventional picture of backward industrial development within a "closed" country and the sudden rise of Japan into a modern national economy. On the contrary, having managed a protective trading policy, a seemingly closed Japan had commanded its own economy, not only in its domestic market, but also in the inter-Asian market.

It is true that the Japanese economic structure presented by Kawakatsu illustrates some historical characteristics of the period. This structure was certainly a factor behind a seemingly sudden surge in Japan's modern industries. Importantly, however, Western science and technology gradually infiltrated into Japan via Dutch activities at the time. The introduction of scientific and technological knowledge could be rightly regarded as being responsible for the transition of the Japanese socio-economic structure and as playing a crucial role in building up such industries. In order to illustrate a comprehensive history of the economic and techno-scientific complex, this paper tries to provide a further account of the technical aspect of metal production.

The issue will be deal with from the perspective of the transfer of science and technology between Europe and Asia. In this regard, I will first review the Dutch colonial scientific activities in the Dutch East Indies, as Dutch scientific activities in Japan were conducted within an extensive framework of Dutch colonial management. Therefore, Japanese metal production will be analyzed in the context of colonial scientific history.

In a broad context, the relationship between knowledge and power is my concern. This can be paraphrased as the relationship between science and politics. Technology will be extracted from science, and economics from politics. Industrialization is the intermediate step. Metal is the material. The scene is eighteenth and nineteenth century Asia, with a backdrop of pre-imperial colonialism and "enlightened" scientific idealism. The "guest" roles are played by Dutch scientists and "host" roles by Japanese scholars. The opening scene is set in the Dutch East Indies, with the so-called "colonial scientists" opening the curtain.

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3 For a changing conception of *Sakoku*, see Arano Yasunori *Kinsei Nihon to Higashi Asia* (1988), R. Toby *State and Diplomacy in Early Modern Japan, Asia in the Development of Tokugawa Bakufu* (1983).

2. Temporal Framework from the 1780's: Western Studies in Japan and Dutch Colonial Sciences

Bearing the general temporal framework of our conference in mind, it is worth noting the establishment of the oldest scholarly society in Asia, Het Bataviaasch Genootschap van Kunsten en Wetenschappen (The Batavian Society of Art and Sciences) in 1778 in Batavia.[4] At the same time, the rising interest in Western studies in Japan in the 1770's, which is marked by the monumental publication of *Kaitai Shinsho* (New Book of Anatomy) in 1774, can be viewed as a related historical event.[5] In my view, a certain intrinsic connection can be discerned in these two seemingly different events. What the Netherlands and Japan had in common in the late eighteenth century was an increasing awareness of the importance of "scientific" inquiry. In other words, they advocated systematic, practical and useful knowledge. On the Japanese side, a pursuit of practical knowledge in medicine reinforced sound empiricism.[6] In disciplines other than medicine, the interest of scholars in Western studies spread, resulting in an overall introduction of Western sciences in the nineteenth century. The political, economic and even philosophical demand for a more organized search of nature was advocated not only by intellectuals, but also by political authorities from the second half of the eighteenth century. Although the concept of "science" had not yet been identified, systematic inquiry into nature had for the first time been initiated and attempts had been made to organize the findings as objective, empirical and practical knowledge.

On the Dutch side, the founders of the Batavian Society aimed at systematic exploitation of natural and human resources in their colonies with the "most proper use of scientific knowledge".[7] Together with the establishment of local scholarly societies in the context of an enlightenmentalist movement for popularization of science in Holland in the middle of the eighteenth century, the Dutch scientific interests in the East Indies were re-organized from sporadic and exotic descriptions to

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4 T. H. der Kinderen *Het Bataviaasch Genootschap van Kunsten en Wetenschappen godurende de eerste eeuw van zijn bestaan 1778-1878* (1878).

5 For Sugita's *Kaitai Shinsho*, see T. Sugimoto *Kaitai Shinsho no Jidai* (1987).

6 Minamoto Ryoen *Tokugawa Gôrishisô no Kenkyû* (1972).
Idem, *Kinsei Shoki Jitsugakushisô no Kenkyû* (1980).
Sugimoto Isao *Kinsei Jitsugakushi no Kenkyû* (1962).
Idem, *Kinsei Nihon no Gakujutsu* (1982).

7 M. J. Sirks *Indisch Natuuronderzoek* (1915).
R. W. van Bemmelen 'Geschiedenis van het geologisch onderzoek in Indonesie', in *Een Eeuw Natuurwetenschap in Indonesie 1850-1950* (1950) 41-48.
H. A. Brouwer 'Geology of the Netherlands East Indies', in *Science in the Netherlands East Indies* (1929) 101-125.

more systematic investigations.[8] There, the usefulness of "scientific" knowledge in natural exploitation was clearly recognized. The organization of "scientific" investigation was thought to be manipulative by the political leadership. Most importantly, such a proposition was an extension of a scientific motive based on humanitarian enlightenment of the eighteenth century. "Scientific and proper exploitation" was innocently advocated for humanitarian reasons.[9] In addition, another stimulus stemmed from the economic motive. For instance, in 1771, Van den Heuvel argued that politically-guided economic promotion should include a colonial perspective.[10] His argument drew attention from the authorities and he was subsequently appointed director of the East Indies' economic affairs. Furthermore, the Oeconomische Tak van de Hollandsche Maatschappij (Economics Department of the Holland Society) was established in 1777, which also covered economic affairs of the Dutch East Indies. The Governor-General, Radermacher, who was one of the active founding members of the Batavian Society, actually cooperated closely with Van den Heuvel. Thus, we see the combination of three factors behind the establishment of the Batavian Society: a scientific motive based on humanitarian enlightenment, economic interest and governmental support for the promotion of colonial sciences. [11]

In order to comprehend the history of colonial sciences, the framework proposed by Basalla is of some use.[12] Basalla discussed "three-stage development", in which he proposed three overlapping phases as follows: (1) an extension of geographical exploration, characterized by the survey of new territories in order to study their physical features including their flora and fauna; (2) a stage of colonial science, characterized by the emergence of certain scientific activities with a reliance on metropolitan science and its institutions; (3) "independent scientific tradition", the final phase which would evolve when there was freedom from metropolitan science, both in research and in training of scientists. In the period before 1816, the Dutch colonial studies in natural science can be characterized by Basalla's first stage. Geological investigation was not mature enough to go beyond natural history and geographical descriptions. The contents of the *Verhandelingen van het Bataviaasch*

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8 H. A. M. Snelders 'Het Bataviaasch Genootschap van Kunsten en Wetenschappen in de periode 1778 tot 1816', in *Documentatieblad Werkgroep 18e Eeuw* 41-42 (1979) 62-90.
T. Yoshida 'Oranda niokeru Kagaku no Taishûka to Rangaku', in *Higashi Ajia no Kagaku* (1982) 50-108.

9 L. Pyenson *Empire of Reason: Exact sciences in Indonesia 1840-1940* (1989).

10 Van den Heuvel's argument took place at an occasion of prize-winning at the "Hollandsche Maatschappij van Wetenschappen' (Holland Society of Sciences). See H. A. M. Snelders 'Het Bataviaasch Gnootschap van Kunsten en Wetenschappen in de Period 1778 tot 1816', in *Documentatieblad Werkgroep 18e Eeuw* 41-42 (1979) 62-90.

11 L. Pyenson 'Pure learning and political economy: science and European expansion in the age of imperialism', in *New Trends in the History of Science* (1989) 209-278.

12 G. Bassala 'The Spread of Western Science', in *Science* CLVI (1967) 277-5.

Genootschap der Kunsten en Wetenschappen (Transactions of the Batavian Society of Art and Sciences) displays an inclination to natural history and geography as Snelders analyzed. The following table shows the number of articles in *Transactions*.[13]

Table 1: Numbers of articles in *Transactions of the Batavian Society of Art and Sciences*, 1-8.

	Vol. 1 (1779)	Vol. 2 (1780)	Vol. 3 (1781)	Vol. 4 (1786)	Vol. 5 (1790)	Vol. 6 (1792)	Vol. 7 (1814)	Vol. 8 (1816)
Medicine	3	5	1	2	1	0	1	0
Physics	0	1	0	0	1	0	2	1
Natural History	3	8	14	10	4	0	4	4
Technology & Agriculture	1	4	4	0	3	1	0	0
Geography	4	5	4	5	0	5	4	2
History & Language	2	7	2	2	0	0	1	3

Geological and mineralogical fields were of their concern only as a part of descriptive science. In this sense, research in this period can also be characterized as being of a supplementary nature: colonial research substitutes for research that cannot be carried out in Europe and which made use of its natural and geographical specialities.[14] Some geological features of Japan were also described from the viewpoint of natural history in this period. One of the earliest descriptions was reported in Thunberg's work.[15] In the framework of scientific research in the East Indies, the first description of Japanese geology and mineralogy can be found in as early as 1776, when Baron von Wurmb listed inventories of Japanese minerals and stones.[16]

After this period, the importance of agriculture was gradually recognized as an economic motor, so the focus of scientific interest came to concentrate on botanical resources. Scientific interests and political-economic demand went through a phase

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13 Snelders 'Het Bataviaasch Genootschap van Kunsten en Wetenschappen in de Period 1778 tot 1816', in *Documentatieblad Werkgroep 18e Eeuw* 41-42 (1979) 82-90.

14 Van Berkel *In het voetspoor van Stevin* (1985) 208-213.

15 C. P. Thunberg *Voyages de C. P. Thunberg au Japon* (1796) 439-445.

16 F. Baron von Wurmb was secretary of the Batavian Society; a list of Japanese minerals and stones reportedly collected by him is published in the *Transactions of the Society* 4 (1786) 566-568. See also J. MacLean 'Natural Science in Japan, I: Before 1830', in *Annals of Science* 30 (1973) 261.

of agrarian management. Stamford Raffles represents this combination for his scientific research was based on an interest in the promotion of agriculture.[17] He broke through a stagnation of scientific research as well: he revived the activities of the Batavian Society. By all means, Raffles was an epoch-maker of Bassala's second phase. He was the personification of scientific research coupled with mercantalistic objectives: scientific studies were closely associated with the promotion of useful crops and the production of commodity goods.

After Raffles, the colonial objective changed structurally from primary agrarian management to raw material supply. In regard to agriculture, more attention was focused on commodity crops. Mineral resources were also given more attention, not only for monetary reasons, but also for industrial reasons. Research methodology on geology certainly began to shift from the natural historical method, the Neptunian method, to the physico-chemical method.

Even after Raffles, however, little research in mining took place, mainly because it was peripheral to national income and because new exploration of mines was still not cost-effective. After restoration of Dutch control over the East Indies, strategy slightly changed. After the French occupation period, the Netherlands needed extensive structural re-organization. According to Kossmann, it was at this time that the Netherlands tried to rescue themselves economically through investment in overseas territories, as the European market had already been saturated.[18] In scientific programs, the leading character of this period was Reinwardt, who proposed the establishment of the botanical garden in Buitenzorg (Bogor). This garden was eventually opened in 1817.[19] He became its first director and organized systematic research. Shortly after the garden opened, the Natuurkundige Commissie voor Nederlands-Indie (Natural Scientific Committee for the Dutch East Indies) was established in 1820. This was in charge of organization and policy-making for the sciences in the colony.[20] Geological studies in this period were implemented by foreign scientists employed in the Dutch East Indies, such as Horsfield and Junghuhn.[21] The pan-European character of the Dutch colonial empire is worth noting. As a small country, the Netherlands made use of European scientists from various backgrounds. For example, Kaempfer was a German; Thunberg, a Swede; Horsfield, an American; Junghuhn, a German; and von Siebold, a German.

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17 S. Shinobu *Ruffles Den* (1968) 174-177, 271-274 and 420-422.

18 J. J. Kossmann *De Lage landen 1600-1980* (1980).

19 For the botanical garden in Bogor, see M. Treub *Geschiedenis van 's Lands Plantentuin te Buitenzorg, van 1817 tot 1844* Mededelingen van's Lands Plantentuin VI (Batavia 1889).

20 For the establishment of the Natuurkundige Commissie, see H. J. Veth *Oversicht van hetgeen, in het bijzonder door Nederland, gedaan is voor de kennis der Fauna van Nederlandsche Indie* (1879).

21 For Junghuhn, see C. W. Wormser *Frans Junghuhn* (1940).

3. The Relationship between Science and Technology in Mining and Metal Production

Nakaoka's proposition should be taken into account in order to discuss the relation between science and technology in mining and metal production.[22] In his historical analysis of the emergence of professional engineering from the end of the eighteenth century to the beginning of the nineteenth century, Nakaoka emphasizes the changing nature of science itself. The establishment of engineering and industrial technology might be characterized in terms of the unification of science and technology. This is, however, not sufficient, because "science" as applied in industry was not "science" of the seventeenth century's scientific revolution *per se*, but a historically restricted entity of knowledge that was socially modified and philosophically confined within a particular context. What is needed is, according to Nakaoka, a close analysis of the nature of the specific science within a given particular context.

In light of the point made by Nakaoka, the state of scientific and technical advancement in mining and metal production in Europe will be briefly reviewed. Mining and metal production is a combined practice, which can be divided into several phases, such as prospecting, mining, hauling, ore-processing and smelting. Mining itself requires an array of mechanical devices, not only for drilling, but also for ventilation, drainage and lighting especially when shafts are sunk deeper and galleries scroll inside. In addition to improvements in machinery, the advancement of ore processing was evident in the stamping, picking, sieving and washing stages. They became more mechanized and exhibited the innovation potential of seventeenth and eighteenth century Europe. At the same time, the improvement of smelting had been met with the application of scientific studies in mineralogy and chemistry, especially those in mid-eighteenth century Swedish practices. In this paper, I will deal more with geological, mineralogical and chemical advancement in mining and metal production than with mechanical technology, because, historically, more attention is given to the improvement of machinery than to the technological contributions from geological and mineralogical development.

Throughout the period of our concern, geological science particularly that of Freiberg was concerned with mining practice.[23] The Wernerian school of geology laid a grand framework in terms of the so-called Neptunian geology. They could discard the old custom of trivial descriptions of "fossils" and extend their observations to

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22 Nakaoka 'Kagaku to Gijutsu no Ittaika to Seidoka', in *Gijutsu Shisô no Hensen* (1981) 133-164.

23 For Freiberg and Wernerian Neptunian geology, see C. C. Gillispie *The Edge of Objectivity* (1960); *Idem*, *Genesis and Geology* (1951); R. Hooykaas *Natural law and divine miracle* (1963). See also, W. Sarjeant *Geologist and the History of Geology* (1980).

"mountains" as a whole. They were also in a position of making Agricola's achievement available, and they actually did so. Neptunian geology faced its rival Vulcanist school in the first half of the nineteenth century, and was also challenged by the Hattonian controversy. Notwithstanding these theoretical challenges, Neptunian influence reached further than European metropolitan scientific discourse assumed. In particular, a descriptive survey on the framework of colonial science was carried out predominantly in a Neptunian manner.

In this period, the discrepancy between mineralogy and geology is discerned. The development of mineralogy in the middle of the eighteenth century was supported by two interrelated areas of crystallography in France and chemical mineralogy in Sweden. In France, a closer look at exterior features inspired mathematical measurement of individual crystals. Rome d'Lyle and Hauy believed that precise and exact description would allow for better classification.[24] Therefore, they established systematic crystallography of minerals. In contrast to this purely mathematical description, the more down-to-earth requirement of acknowledging component elements of minerals incurred the development of mineralogy which was subdued in mining practice in Sweden. Swedish chemical mineralogists, such as Cronstedt and Bergman, synthesized assay techniques into a systematic inquiry of minerals. Compilation of practical chemical techniques for mineral assay led to a breakthrough in surveying.[25] Since it was the metal element in minerals that was needed, chemical mineralogy meant more to later mining practice than did sheer mathematical and exact crystallography. The combination of Neptunian geology and chemical mineralogy was the major scientific contribution to eighteenth and nineteenth century mining and metal production.

In its initial phase, the infiltration of geological science into Japan was characterized by the introduction of Neptunian geology rather than crystallographical mineralogy or chemical mineralogy. Neptunian geology was also associated with military surveying of strategic geography. This can be seen in some works by A. von Humbold. According to Cannon's argument, the influence of Von Humbold was so significant that the methodology used by the following generation of explorers was characterized as the "Humboldian method".[26] One of the essential factors of this "Humboldian method" was geographical and geological observation of Neptunism,

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24 R. Hooykaas *Geschiedenis der natuurwetenscahppen* (1976).

25 T. M. Porter 'The promotion of mining and the advancement of science: the chemical revolution of mining', in *Annals of Science* 38 (1981) 543-570.
D. R. Oldroyd 'Mineralogy and the "Chemical Revolution"', in *Centaurus* 19 (1975) 54-71.
J. W Llana 'A contribution of natural history to the chemical revolution in France', in *Ambix* 32-2 (1985) 71-91.

26 In F. Canon 'The Uniformitarian-Catastorophist Debate', in *Isis* 51 (1960) 38-65.

the means by which Ruffles, Thunberg and Von Siebold also carried out their research.

4. Von Siebold's Contribution to Japanese Geology

The introduction of Western science to Japan via Dutch sources flourished by 1800.[27] The Dutch trading station at Deshima was the point of dissemination of Western information in Japan. Scientific literature was sporadically but gradually brought in. Officials who were in charge of interpreting the Dutch language gradually spread scientific information and a Rangaku (Dutch Studies) scientific community was formed. Initially, Dutch Studies focused on the subjects of astronomy and medicine. Later, these became more specialized, corresponding to their Western counterparts. The first knowledge on Western geology to be brought to Japan was in the form of a Dutch encyclopedia by Chomel.[28] The translation project of the encyclopedia organized by the government was inaugurated in 1811. The following articles relating to geological items were translated: Earth, Clay, Metallurgy, Agate, Amethyst, Asbest, Antimony, Ash, Alum.[29] Those, which are discussed according to Neptunist geology, were completely different from the traditional Japanese view of "growing minerals embedded in various rocks" according to the function of "Five Elements and Two Fundamental Forces, Yin and Yang" as described in the gigantic classic work, *Unkonshi*, by Kiuchi Sekitei.[30]

Two different currents, the Dutch overseas scientific approach and the Japanese interest in Western sciences, had an opportunity for direct exchange in the 1820's. Assigned to promote trade and industry, Von Siebold was sent to Japan in 1824. Shortly before his dispatch, he was appointed a corresponding member of the Batavian Society.[31]

The dispatch of Von Siebold and a pharmacist, H. Bürger, marked a new step in the history of science in Japan. They contributed to the dissemination of modern Western science mainly in the field of medicine. Bed-side clinical education was conducted and systematic scientific instruction was, for the first time, delivered at their private school, Narutakijuku. Their contribution is practically evident in the

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27 J. Numata *Yôgaku* (1989).

28 T. Itazawa *Nichiran Bunka Kôshôshi no Kenkyû* (1959) 264-297.
Y. Sugano '*Chomel* Orandagoban', in *Nihon Yôgakushi no Kenkyû* III (1974) 71-112.

29 *Kosei Shinpen* reprint in 1937.
M. Doi *Wagakuni no 19 Seiki niokeru Kindai Chigakushisô no Denpa to sono Hôga* (1978).

30 For a Neo-Confucian view of earth and minerals, see *Mathematics and the sciences of the heaven and earth*, Vol. 3, in J. Needham *Science and Civilisation in China* (1956). For an early history of geological sciences in Japan, see K. Mochizuki *Nihon Chigakushi*, and I. Imai *Reimeiki no Nihon Chishitsugaku* (1966).

31 *Transactions of the Batavian Society* 9 (1823) xi and xxxvii.

specialization of sciences in Rangaku. With regard to geological research, not only Neptunian geology, but also the first infiltration of chemical mineralogy was ascribed to their contribution.

Scientific activities conducted by Von Siebold should be understood from the viewpoint of colonial sciences. Scientific activities in the period of our concern had never been a "pure" issue of knowledge, but were politically interwoven. Today, in the aftermath of "scientific" rampancy, we cannot remain simply naive and believe the nature of "science" to be fundamentally good. The case of Von Siebold is no exception, although he often used to be viewed as a "benefactor" of the introduction of modern Western science in Japan.[32] Such a view, though, can only be derived from a "Whig interpretation of history".[33] The dual nature of his scientific activities should thus be a focal point. He disseminated medical and scientific knowledge as a "benefactor", while he acted as a perfect colonial scientist. Using Said's argument, for instance, Friese regarded Von Siebold as an exemplification of "Orientalism".[34] Parallels can be drawn between the exploitation of indigenous informants and those in Dutch Javanese studies, as revealed by Tsuchiya.[35] Through an analysis of Von Siebold's work, light will be shed on the dual character of his scientific activities.

4.1. New lift on the manuscript of the Bet unpublished "Geologica Japonica": addition of chemical mineralogy to Wernerian geology; analyses of mineral water.

Geological studies by Von Siebold and Bürger were peripheral even within the perspective of natural history. In comparison with the other natural kingdoms, for which two vast series of publications, "Flora Japonica" and "Fauna Japonica", were dedicated, "Geologica Japonica" had not yet been written. Recently, however, a manuscript related to their geological survey was found in the Von Siebold archives in the University of Bochum, Germany, as a result of my investigations.[36] Geological and mineralogical research for this was identified as having been carried out in 1824-1829. The manuscript was determined to have been handwritten by Bürger. This is most probably a draft of "Geologica Japonica". The contents are as follows: an overall

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32 For activities of Von Siebold and Bürger, see Tsukahara *A Study on the beginning of chemistry and chemical education in Japan: with special reference to the contribution of Ph. F. von Siebold and H. Bürger in the first half of the nineteenth century* (1987).

33 H. Butterfield *The Whiggish Interpretation of History* (1931).
Idem, *The origin of modern science, 1300-1800* (1957).

34 E. Friese *Phillip Franz von Siebold als früher Exponent der Ostasienwissenschaften: ein Beitrag zur Orientalismus-diskussion und zur Geschichte der europäisch-japanischen Begegenung* (1983).

35 K. Tsuchiya '19 Seiki Jawa Bunkaron Josetsu: Jawagaku niokeru Rongowarushito no Jidai', in *Tônan Ajia no Seiji to Bunka* (1984) 71-127.

36 T. Tsukahara 'Nishi Doitsu Ruhr Daibaku, Bochum, ni Genzon suru Siebold Kankei Bunsho chûno Chishitsugakuteki Chôsa Kenkyû nitsuite', in *Nichiran Gakkai Kaishi* 15-1/29 (1990) 57-77.

observation of physical geology with an insight of "geognosy"; specific descriptions of individual rocks and minerals found in Japan in the manner of "oryktognosy"; the results of analyses of mineral water from II different hot water springs; mining and smelting of copper in Japan; the state of mineralogical studies in Japan; a list of Japanese (volcanic) mountains (see Figure 1).

There were two strategic intentions. Firstly, the primary interest was in extensive geographical description. It was modelled after "Humboldian" methodology, a tradition in geological survey for explorers of "Terra incognita". Secondly, a particular interest in valuable minerals was obvious. In the section on descriptive mineralogy (which is called "oryktognosy" in Neptunian terms), in particular, Bürger extensively discussed sample localities (places where minerals were to be found), quality and percentage of metals contained, and yearly production from specific mines for further mining possibilities. For copper mining, Bürger made a separate chapter, to be discussed later in this paper.

As the terminology shows, their survey was carried out in the ways of the Wernerian school of Neptunism. The Wernerian influence on Von Siebold and Bürger is also evident from a list of geological and mineralogical books at Von Siebold's disposal in 1823.[37] The titles known so far, which relate to their geological studies are:

- C. A. S. Hoffmann, *Handbuch der Mineralogie, fortgesetzt von August Breithaupt*, 1811-1818.
- J. F. A. Breithaupt, *Über die Aechitheit der Crystalle*, 1815.
- A. G. Werner, *Letztes Mineralsystem, aus dessen Nachlass hrsg. von J. K. Freisleben, mit Erläuterungen von Breihaupt und Custos Köhler*, 1813.
- K. W. G. Kastner, *Grundriss der Experimentalphysik*, 1820-1822.
- S. F. Hermstaedt, *Systematischer Grundriss der allgemeinen Experimentalchemie zum Gebrauch der Vorlesungen entworfen*, 1812-1824.
- J. F. John, *Chemisches Laboratorium oder Anweisung zur chemischen Analyse der Naturalien, nebst Darstellung der nöthigsten Reagenzien*, 1808-1821
- G. F. Parrot, *Grundeniss der theoretischen Physik*, Thl. 1,2,3, and *Grundeniss der Physik der Erden und Geologie*, 1815.

It appears certain that Von Siebold and Bürger benefited from the reading of these works. Chemical mineralogy is incorporated in the works of John and Parrot. A manuscript of Bürger's analyses of mineral water used their methods, as well. The motives for knowing the ingredients of different sorts of mineral water did not only stem from geological interest, but were also associated with its therapeutic use in this age. The application of the chemical method was, at the same time, a sign of the outgrowth from conventional research in natural history. Bürger's chemical analysis

37 Takeuchi '1823 nen Siebold ga Ôshû to Batavia kara Hakusai sase 25 nen Nagasaki de ukettota Shoseki to sonogono Unmei', in *Nichiran Gakkai Kaishi* 8-1 (1983) 1-20.

was only qualitative; yet it was systematic in that it used about ten different chemical reagents to assay whether a specific mineral water contained a particular chemical body. For instance, chemical examination followed this order:[38]

1. Add limewater (whether the mineral water becomes cloudy).
2. Add lead acetate (any precipitation).
3. Add ferrous (ferric) sulphate (green).
4. Add concentrated hydrochloric acid (any foaming).
5. Add gallic acid (cloudy).
6. Add iron prussiac kali (change of color).
7. Add barium hydrochlorite (precipitation).
8. Add silver nitrate (cloudy).

Using almost the same methods, more analyses of mineral water were carried out by a Japanese Rangaku scholar, Udagawa Yoan. He had some exchange with, and was certainly inspired by, Von Siebold and Bürger on the occasion of their visit to Edo in 1826.[39] Udagawa's contribution to the establishment of chemistry in Japan was outstanding, as represented by his extensive work, *Seimi Kaiso*.[40] A transfer of chemical experimental techniques can be seen here in the analysis of mineral water, which was performed in relation to the framework of geological research, too.

4.2. Survey of coal mines and an attempt at tea transplantation from Japan to Java

Other evidence will support the view that Von Siebold and Bürger's investigations were deeply influenced by Dutch scientific strategies, with an ultimate task of resource-seeking. Apart from the above-mentioned file, manuscripts on the survey of useful minerals, such as coal in the Chikuzen (Fukuoka) area, were also found (Figure 2).[41] For this research, Von Siebold effectively used "reports" from his students who attended his Narutaki school.[42] It is worth noting that his extensive use of local informants can be considered a form of primary exploitation of indigenous knowledge.

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38 For an analysis of mineral water, see T. Tsukahara *A Study on the Beginning of Chemistry and Chemical Education in Japan* (1987).

39 For the diary of von Siebold, and autobiography of Yoan, see T. Kikuchi 'Yoan Nenpu Chusyaku', in *Seimi Kaiso Kenkyu* (1975) 115-131, and M. Koda 'Udagawa Yoan no Nenpu (Jo)', in *Tsuyama Kôsen Kiyô* 29 (1992) 179-220.

40 For *Seimi Kaiso*, see Tanaka, ed. *Seimi Kaiso* (rep. 1975).
See also Tsukahara *Affinity and Shinwa Ryoku: Introduction of Western chemical concepts in early nineteenth-century Japan* (1993).

41 For manuscripts on coal mines, see V. Schmidt, 1.379.000. (1989) 284 entitled 'Wenige vragen betreffende de steenkolen levering van den Vorst van Tsikuzen'.

42 For the "reports" from students, see T. Okubo, et al. 'Monjin ga Siebold ni Teikyô shitaru Rango Ronbun no Kenkyû', in *Siebold Kenkyû* (1938).

A manuscript dealing with chemical research on the soil of a tea plantation in Ureshino, Kyushu, was also found (Figure 3).[43] This investigation was carried out with the intention of cultivating Japanese tea shrubs in Java at colonial plantations.[44] Later, in Java, some experiments in tea transplantation were carried out within the framework of Dutch colonial scientific attempts: it was Von Siebold who collected and sent several species of tea seeds and shrubs to Java, scientists affiliated with the colonial botanical garden in Buitenzorg (Bogor) and members of the Batavian Society.

All these investigations are comparable to so-called "feasibility studies" used in modern day development projects. The accuracy, though, of these studies in predicting the future is a great surprise. Their research anticipated later economic development such as fertile coal mines in the Chikuho area of Northern Kyushu, which later supplied the iron industry in Japan. Needless to say, tea plantations in Java became a profitable business for Dutch colonists.

4.3. The Investigation of Copper

4.3.1. Visit to Sumitomo copper refinery at Osaka. and acquisition of metallurgical samples including copper ores and "stick copper"

On the occasion of their trip to Edo, Von Siebold and Bürger dropped in on the Sumitomo family and looked at the Sumitomo copper refinery.[45] According to a diary of Von Siebold's, dated June 11th, 1826, they were welcomed by a "Dutchphile" merchant. They had a pleasant talk with him and made an interesting observation of the refinery. The merchant presented them with a "souvenir".[46] This visit was also recorded in the Sumitomo archives in the form of a booklet entitled "A Note on a Visit of Red-haired People" (1826, May 6. N.B. Lunar calendar, see Figure 4).[47] This notes the names of the visitors and hosts, the "Menu" prepared to treat them, and the gift presented to them. The gift is of importance, for it lists "a package of copper

43 For manuscripts concerning tea cultivation, see V. Schmidt *Op. cit.*, 123-126: Theodor Friedrich Ludwig Nees von Esenbeck, Unterschrift unter den Notizen über verschiedene Arten des Teestrauches, u.s.w. Beschreibung des Theestrauches Tea Sinensis Linn.

44 For tea transplantation from Japan to Jawa, see Ishiyama 'Nihon niokeru Chaju no Saibai to Cha no Seihô', in *Siebold 'Nippon no Kenkyuûto Kaisetsu* (1977) 179-184.

45 Von Siebold was, however, not the first to get there. Thunberg had been there as well in 1776. The earliest known record of a visit to the Sumitomo refinery is as early as 1690, as noted in a diary by Opperhoofd Dijkman. Also see H. Shoji 'Orandajin to Izumiya to Osaka Dôfukijô', in *Sakoku Nihon to Kokusai Kôryû* 2.
For *Kodô Zuroku*, see K. Nishio *Nihon Kôgyôshiyo* (1943) 164-188. *Kodô Zuroku* has been reprinted many times. See Saegusa's reprint version.

46 The diary of von Siebold was reprinted in 1975 by Kodansha, and its Japanese translation was published in 1977-1979 by Yushodo.

47 Through the courtesy of Mr. T. Sueoka & Mr. Kawasaki, of the Sumitomo Archives, the note entitled "Kômôjin Nyûai no Hikae" is reproduced for this study. See also, K. Imai 'Siebold no Sankan seru Sumitomo no Dôfukijô', in *Ika* (Sumitomo Shanaishi) 232 (1934) 36-45.

ores", which is considered to have contained copper minerals, smelting, slag, intermediate products and refined copper. In addition to these, *Kodô Zuroku*, a copper mining and smelting book, was also presented to Von Siebold.

One may wonder where these gift samples of copper ores and intermediate products of copper are now. They were recently identified in the Netherlands. A collection of rocks and minerals, including fossils and artistic objects *(Suiseki)* in the Muses of Geology and Mineralogy, Leiden, was first examined by M. Osawa in 1983 (Figure 5).[48] Following Osawa's findings, closer research into this collection was carried out by the author of this paper with the cooperation of Arps of the museum. As a result, some of the copper ores were identified as originating from the Besshi mine in the Iyo domain (Ehime prefecture) in Shikoku, which, in Von Siebold's day, was involved in the Sumitomo mining industry. Several pieces of slag from the smelting process are most probably from the Sumitomo refinery. These are the gifts from the Sumitomos to Von Siebold. Two pieces of stick-shaped copper, "Saodo", were also found. These objects are valuable, not only in that they substantiate Von Siebold's interests in Japanese mining, but also that they are able to provide some references with regards to recent excavations of the Sumitomo refinery in Osaka.[49] In the collection, at least three different acquisitions can be identified, but they were all put together at the Museum's convenience under the name "Von Siebold Collection". Here again, Bürger's contribution is not negligible. My examination could illustrate that it was Bürger rather than Von Siebold who constructed a whole series of collections of rocks and minerals. There is also proof that geological parts of Von Siebold's research program were carried out by Bürger.

The collection is primarily classified according to Hoffman's system with Wernerian nomenclature. As can be seen in Figure 5, it is noteworthy that binary nomenclature by Hauy was also attached. A remarkable point in Hauy's binary nomenclature is that it indicates the chemical composition of specific minerals. This collection also corresponded to the description of Bürger's manuscript on Japanese minerals. Specimens found are listed in Table 2 in reference to Hoffman's and Bürger's works.

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48 Osawa's report is in the *Nihoran Gakkai Kaihô* (1987). He also presented preliminary research results at the occasion of the annual meeting of the Japanese Society of History of Science in 1983. See also, T. Tsukahara and M. Osawa 'On the Siebold Collection of crude drugs and related materials from Japan', in *Bulletin of Tokyo Gakugei University, Section IV, Mathematics and Natural Sciences* 41 (1989) 41-97.

49 For the excavation project of Sumitomo refinery, see N. Haga 'Wagakuni Dô Kaihatsu no Rekishi nitsuite', in *Enerugii Shigen* 5.3 (1984) 256-262; *Idem*, 'Nagabori Dôfukijô ato', in *Shigen Sozai Gakkaishi* 106.12 (1990) 760; and *Idem*, 'Sumitomo Dôfukijô', in *Kinzoku* (May 1991) 70-77.

Table 2: List of specimen found in Rijksmuseum van Geologie en Mineralogie. According to Bürger's classification & Hoffman's reference.

Geognostische Ubersicht der Lagerstadt von denen bisjetzt vorgefundenen oryktognostischen Fossilien, H. Bürger. (Manuscript by Bürger)

In brackets [---] following Bürger's specification of the specimen is reference page in the book of Hoffmann's *Handbuch der Mineralogy* [number of volume. page.]

I. Klasse Erdige Fossilien	[I.p.353]
Kieselgeschlecht	[I.p.422]
Granat,W. Grenat,H.	[I.p.491]
Topas,W. Topaze,H.	[I.p.577]
Schörl,W. Tourmaline,H.	[I.p.626]
Quarz,W. Quartz hyalin,H,	[II.a.p.1]
Eisenkiesel,W, Quartz hyalin rubigineux,H.	[II.a.p.60]
Horzstein,W. Quarz agathe,H	[II.a.p.65-185]
Feuerstein,W. Quartz agathe pyromaque,H.	[II.a.p.83]
Kalzedon,W. Quartz agathe calcédoine,H.	[II.a.p.108]
Opal.W. Quartz resinite,H.	[II.a.p.144-156]
Jaspis,W. Quartz jaspe,H,	[II.a.p.172]
Obsidian,W. Lave vitreuse obsidienne,H.	[II.a.p.191]
Bimstein,W. Lave vitreuse pumicée,H.	[II.a.p.213]
Feldspath,W. Feld spath,H.	[II.a.p.295]
Thon Geschlecht	[II.b.p.1]
Porzellanerde,W. Feldspath argiliforme,H.	[II.b.p.10]
Schiefer Thon,W. Argile schisteuse,H.	[II.b.p.56,66]
Thonschiefer,W. Argile schisteus tabulaire,H.	[II.b.p.111]
Glimmer,W. Mica,H.	[II.b.p.115]
Hornblende,W. Amphibole,H.	[II.b.p.146]
Basalt,W. Basalte,H.	[II.b.p.162-174]
Klingstein,W. Feldspath compacte sonore,H.	[II.b.p.180]
Lava,W. Lava,H.	[II.b.p.187-213]
Talk Geschecht	[II.b.p.214]
Speckstein,W. Talc stéatite,H.	[II.b.p.236]
Bildstein,W. Talc glaphique,H.	[II.b.p.244]
Serpentin,W. Roche serpentineuse,H.	[II.b.p.255]
Talk,W. Talc,H.	[II.b.p.267]
Asbest,W. Asbeste,H.	[II.b.p.277]
Strahlstein,W. Actinote,H.	[II.b.p.293]
Kalk Geschecht	[III.a.p.1]
Kalkstein,W. Chaux carbonatée,H.	[III.a.p.2]
Kalksinter,W Chaux carbonatée cocretionée,H.	[III.a.p.32]
Erbtenstein,W. Chaux carbonatée concretionée globuliforme,H.	[III.a.p.36]
Kalktuf,W. Chaux carbonatée cocretionée .incrustante,H.	[III.a.p.40]
Rautenspath,W. Chaux carbonatée magnesifére,H.	[II.a.p.48, 57, 60]
Flussspath,W. Chaux fluatée,H.	[II.a.p.94]
Gips,W. Chaux sulfatée,H.	[III.a.p.105]
Fraueneis,W. Chaux sulfatée form:det: H.	[III.a.p.117]
Barijt Geschecht	[III.a.p.185]
Schwerfspathes,W. Barijte sulfatée,H.	[III.a.p.155]
II Klssse Salzige Fossilien	[III.a.p.208]
Kupfer und Eisenvitriol,W. Cuivre sulfaté et fer sulfaté,H.	[III.a.p.235]

III Klasse Brenliche Fossilien	[III.a.p.247]
Schwefel Geslecht	[III.a.p.252]
Vulkanischer Schwefel,W. Soufre volcanique,H.	[III.a.p.262]
Natürliche Schwefel,W. Soufre,H.	[III.a.p.252]
Erdharz Geschecht	[III.a.p.264]
Erdöl,W. Bitume liquide brun ou noirâtre,H.	[III.a.p.266]
Braunkohle,W. Houille,H.	[III.a.p.277]
Schwarzkohle,W. Houille,H.	[III.a.p.291]
Mineralische Holzkohle,W.	[Graphit Geschecht, III.a.p.319]
Resin Geschecht	[III.a.p.323]
Bernstein,W. Succin,H.	[III.a.p.324]
IV. Klasse Metallische Fossilien	[III.b.p.1]
Gold Geschlecht	[III.b.p.10]
Gediegen Gold,W. Or natif,H.	[III.b.p.10]
Quecksilber Geschlecht	[III.b.p.18]
Zinnober,W. Mercure sulfuré,H.	[III.b.p.26]
Natürlich Amalgam,W. Mercure argental,H.	[III.b.p.21]
Quecksilber Lebererz,W. Mercure sulfuré bituminifére,H.	[III.b.p.33]
Silber Geschlecht	[III.b.p.38]
Gediegen Silber,W, Argent natif,H.	[III.b.p.38]
Spiessglanz und Arseniksilber,W. Argent antimonial et Argent antimonial arsenifere,H.	[III.b.p.46,48]
Glaserz,W. Argent sulfuré,H.	[III.b.p.57]
KupferGeschlecht	[III.b.p.83]
Gediegen Kupfer,W. Cuivre natif,H.	[III.b.p.84]
Rothkupfererz,W. Cuivre oxydulé,H.	[III.b.p.89]
Kupferglas,W. Cuivre sulfuré,H.	[III.b.p.103]
Buntkupfererz,W. Cuivre pyrite hepatique,H.	[III.b.p.110]
Kupferkies,W. Cuivre pyriteux,H.	[III.b.p.113]
Fahlerz,W. Cuivre gris arsenifére,H.	[III.b.p.119]
Kupferlasur,W. Cuivre carbonatée bleu,H.	[III.b.p.134]
Malachit,W. Cuivre carboté vert,H.	[III.b.p.144]
Eisen Geschlecht	[III.b.p.186]
Schwefelkies,W. Fer sulfuré,H.	[III.b.p.190]
Magneteisenstein,W.Fer oxydulé,H.	[III.b.p.216]
Magnetischer Eisensand,W. Fer oxydulé granulair,H.	[III.b.p.223]
Eisengalnz,W. Fer oligiste,H.	[III.b.p.229]
Roth und Brauneisenocker,W. Fer oxydé pulverulente,H.	[III.b.p.254]
Eiseniere,W. Fer oxydé geodique,H.	[III.b.p.286]
Blei Geschlecht	[IV. 7) Blei]
Zinn Geschlecht	[IV. 8) Zinn]
Wissmuth Geschlecht	[IV. 9) Wismuth]
Zink Geschlecht	[IV. 10) Zink]
Blende,W. Zinc sulfuré,H.	[IV.a.p.73]
Antimon Geschlecht	[IV. 11) Antimon]
Grauspiessglanzerz,W. Antimoine sulfuré,H.	[IV.a.p.102]
Mangan Geschlecht	[IV. 13) Mangan]
Manganspath,W. Manganése oxydé carboté,H.	[IV.a.p.155]
Kobald Geschlecht	[IV. 15) Kobald]
Weisseer Speisskobalt,W. Cobalt arsenical,H.	[IV.a.p.173,174]

Arsenik Geschlecht	[IV. 16) Arsenik]
Arsenikkies,W. Fer Arsenioal,H.	[IV.a.p.211]
Rauschgelb,W. Arsenic sulfuré,H.	[IV.a.p.220]

4.3.2. Bürger's article on Japanese copper based on *Kodô Zuroku*

Bürger wrote an article on Japanese copper based on *Kodô Zuroku,* and published it in *The Transactions of the Batavian Society of Art and Sciences*. He discussed the visit to the Sumitomo copper refinery as well, and widely cited the *Kodô Zuroku* which was given to Von Siebold by the Sumitomos on the occasion of their visit. This *Kodô Zuroku* used by Bürger can be found in the National Museum of Ethnography in Leiden (Figure 6).[50]

The fact that Bürger reported on Japanese copper in Dutch is evidence of an exchange of geological and mining knowledge between Europe and Asia. It is my intention to contribute to the follow-up of Vogel's study at our last conference, in that he clarified the transmission of Agricola's *De Re Metallica* into China during the years from 1638 to 1640 by the Jesuit Johann Adam Schall von Bell.[51] Vogel pointed out that the translation of *De Re Metallica* was dictated by the fiscal importance of the Right Vice-Minister of the Board of War, Yang Ssu-ch'ang, who appealed for the promotion of mining, although the upsurge in the promotion of mining was controversial between the late Ming military officials and the civil officials. The latter emphasized the negative social, economic and ecological aspects of mining and stuck to the agricultural advantages. Mining was also held responsible for disturbing geomancial features of the landscape. All in all, unlike Europe, rulers and officials in China generally thought less positively of mining and smelting activities. Nevertheless, European mining literature was welcomed and consumed by a variety of people of different social strata. Since miners and smelters were mostly illiterate and occupied a low rank in the social hierarchy, influence of such literature was mostly limited to officials and scholars. Vogel further noted that recipients of the *De Re Metallica* in China were officials, while in Japan they were entrepreneurs, such as the founder of Sumitomo. It was due to the efforts of these entrepreneurs, that the Japanese could utilize such techniques as the liquation process (Seigerprozess), and the separation of copper and silver by means of lead mediation.

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50 *Kodô Zuroku* in *Rijksmuseum voor Volkenkunde* is listed in the catalogue by L. Serrurier *Bibliothéque Japonaise: Catalogue Raisonné des livres et des manuscrits Japonais enrégistrés à la bibliothéque de l'université de Leyde* nr 901 (1896) 204.

51 H. U. Vogel 'The Transfer of Mining and Smelting Technology between Asia and Europe in the Sixteenth to Early Nineteenth Century', in the *Journal of the Japan-Netherlands Institute* III (1991) 74-101.

Bürger's article shows the reverse of this process, namely the transfer of technical information from the East to the West. The article, entitled "Beschrijving der Japansche Kopermijnen en der Bereiding van het Koper" (Description of Japanese copper mines and the preparation of copper), was published in *Transactions of the Batavian Society* in 1836 (Figure 7).[52] As the title shows, he outlined the copper industry in Japan with a short report of his visit to the Sumitomo refinery. Most of the technical information is based on *Kodô Zuroku.* He also provided specimens of copper ore with scientific names in both Wernerian (Dutch version) and Hauy's nomenclature. "Koperglas (cuivre sulfuré, H.)" and "bontkopererts (cuivre pyrite heptique, H.)" are such examples. It is worth noting that he also mentioned the amount of annual production of copper at several mines in Japan, though its source was not specified. Bürger discussed the reason for the typical red surface of Japanese copper as well. Although the Japanese speculated the red color to be a result of final molding in water, Bürger suspected it was a result of later treatment with high temperature steam on the surface in accordance with Hermbstead's *Experimentaal chemie* (Figure 8). He also pointed out the high content of silver in Japanese copper ores, and the separation of it using lead, the so-called liquation method, *Seigenprozess* or *zaigeeren* process, which was practiced by Sumitomo. Bürger said that the method was introduced by Hakuzui, a Portugese, around 1590, and the method had already been referred to in the Chinese classic *Ten-ko-kei-buts (Tenkoukaibutsu).* Copper business provided wealth to the Sumitomo family, a prosperous industrial-financial concern even today. Obata's discussion clarifies the historical and technical background on this method. Bürger witnessed and described the detailed practices involved in this process.

Japanese copper mining and refineries attracted attention from other business concerns: not only from Dutch traders, but from overseas British researchers. Yoshida found an English article based on *Kodô Zuroku* published in Canton in *Chinese Repository* in 1840.[53] This journal was edited by missionaries, and the article was written by Williams who reportedly acquired *Kodô Zuroku* through a friend of "Mr. Bürger of Deshima". Historical facts concerning this topic, that is to say, how and when Williams got *Kodô Zuroku,* how he could read Japanese text, or whether there were any Japanese who could translate the book for him, how the Dutch and the British made contact on these scientific issues, and so on, remain to be investigated. However, it is abundantly clear that technical procedures for Japanese copper

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52 H. Bürger 'Beschrijving der Japansche Kopermijnen en der bereiding van het koper', in *Verhandelingen van het Bataviaasch Genootschap van Kunsten en Wetenschappen* 16 (1836) 1-28.

53 An English article on *Kodô Zuroku* can be found in the *Chinese Repository* 9 (1840) 86-101. See also, M. Yoshida 'Kodô Zuroku no Eiyaku', in *Kagaku Gijyutsushi Kenkyû* 2 (1968) 1-5. For *Kodô Zuroku,* see also, A. Fujino *Dô no Bunkashi* (1991).

production attracted the interest of both the Dutch and British overseas researchers in the Far Eastern territories.

5. Geological Sciences in Japan after the Impact of Von Siebold: Udagawa Yoan, Mitsukuri Shogo and Sakuma Shozan

Having been stimulated by Von Siebold and Bürger, various kinds of geological studies developed in Japan. For instance, within the framework of his chemical study, Udagawa Yoan referred to the geological formation of the earth in a chapter on silica as follows: "[In Europe,] scholars involved in studies of geological features stipulate that there are three different kinds of new and old mountains: the first are called 'Original Mountains' (Oorspronklijk Bergen), which contain silica type stones such as granite and agate; the second are called 'Successively Formed Mountains' (Daarnagevormde Bergen) or 'Chalk Mountains', which produce chalk earth such as marble and asbestos; the third are called 'Lastly Produced Mountains' (Laast Voortgebragte Bergen). They produce stones in the shape of animals and plants, such as petrified wood, divinely-old-cedar, dragon's bone, and fossil fish, Jusper, diamond, gold, silver, copper and iron. This kind of mountain was young and formed after the big flood."[54] It is identified that Udagawa based this description on O. Segur's *Brieven over. de Grondbeginselen der Scheikunde; door Octavius Segur, gewezen leerling bij de polytechnische school. In gerigt volgens de Lessen der Hoogleeraren Bertholet, Fourcroy, Chaptal, enz.* (1811) (Letters on principles of chemistry: by Octavius Segur, a student attending the polytechnic school. Written following lessons by Professors Bertholet, Fourcroy, Chaptal, and so on).[55] As the title indicates, this work is based on the then up-to-date French technical education, notably that of "Ecole polytechnique". It is worth noting that the contents of the lectures at the "Ecole" were transmitted to Japan via Dutch translation. This exemplifies, too, the infiltration of European knowledge to Japan.

Mitsukuri Shogo also furthered geological study. He discussed the geological formation of the earth in his work on world geography, *Konyo Zushiki* (1846).[56] There he classified mountains into eight categories: 1. Old Mountains; 2. Chalk Mountains; 3. Gips Mountains; 4. Salt Mountains; 5. Kereet (?) Mountains; 6. Coal Mountains; 7.

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54 Udagawa Yoan, 1837-1847, *Seimi Kaiso* 8, Ch. 160.

55 A bibliographical description of Segur's work is in: *Brieven over de Grondbeginselen der Scheikunde: door Octavius Segur, gewezen leerling bij de polytechnische school. Ingerigt volgens de Lessen der Hoogleeraren Bertholet, Fourcoy, Chaptal, enz.* In het Nederduitsch overgezet en met aanteekeningen vermeerderd, door M. J. Reynhout, Medicine Studiosus op de Leidsche Universiteit. Te Rotterdam, bij in. Locke 1811.
See also, Tsukahara *Affinity and Shinwa Ryoku* (1993).

56 Mitsukumi Genpo *Kon'yo Zushiki* 1 (1846).
M. Doi *Wagakuni no 19 Seiki niokeru Kindai Chigakushisô no Denpa to sono Hôga* (1978).

Karamain (?) Mountains; 8. Basalt Mountains. This work was influential, especially for those who feared a military advance by Western powers to gain basic knowledge on world geography. Even such a proponent of nationalism as Yoshida Shoin was said to have scrutinized this work. Although in general, the contents of physical aspects of geography in this work attracted less attention, Mitsukuri's reference to the geological features of the earth resonated in the strategic minds of sea defense advocates, such as Sakuma Shozan. Inspired by Mitsukuri's work, Sakuma carried out a field survey in 1847-1849 in the Shinano domain, Nagano Prefecture, and eventually discovered several useful minerals such as copper, lead and zinc ores.[57] His field survey was notable not only because he was one of the first Japanese to carry out field geology using European methods, but also because he was always aware of the need for an immediate application of "knowledge". He tried to combine the economic interest and strategic purpose of geology. The fact that he had already advocated the pioneering of the frontier of Hokkaido in 1858, is also evidence of Sakuma's foresight in the relationship between geological commitment and politics. In other words, he was a sheer exponent of those who realized the relationship between "knowledge" and "power".

6. Mining in the Dutch East Indies Towards the 1870's

Changes in mining practice in the Dutch East Indies in the 1840's and 1850's will be summarized briefly due to spatial restrictions. This period was marked by different attitudes of colonial commitment: from trading partner to ruler. As for agrarian management, the *cultuurstelsel* (culture system) really began to take effect in this period.[58] There was a subsequent change in the strategy of geological exploitation in accordance with this policy. The earliest administrative control in mining by "Het Koninkijk Besluit van 1850" was proclaimed, in view of tin mines on the Banka island, by Billiton and Singkep Maatschapij.[59] Coal and other mineral resources came to attract more attention, and the potential for exploiting petroleum in particular was

57 For Sakuma, see R. Matsuura 'Risô no Yukue: Seiji wa Shisô to nariurunoka', in *Sakuma Shozan Yokoi Shonan* (1970) 7-85. Sakuma's geological field note is included in his diary entitled, 'Kutsuno Nikki' [Kutsuno Diary] (1848-), which is translated and published in R. Matsuura, ed. *Sakuma Shozan Yokoi Shonan* (1970) 206-250. Sakuma could read some Dutch books. In regards to our topic, he read P. J. Kasteleyn *Beschouwende en werkende pharmaceutische, oeconomische en natuurkundige chemie* (1783) which includes some articles about chemical compositions of earth, rocks and minerals.

58 C. Fosseur 'Tussen Daendels en Van Heutsz: Het Nederlandse bestuur op Java in de 19de Eeuw', in *Spiegel Historiae* 23-10 (1988) 413-419.

59 E. P. Wellenstein *Het Indische Mijnbouwvraagstuk* (1918).

openly discussed.[60] The Museum of Geology in Bandung, was also established in this period as a "cathedral for scientists" in the colonies.[61]

In the 1860's and the 1870's, one saw the institutionalization of studies concerning mining: university education was formalized, scientific societies were inaugurated, and a number of journals were started. For example, *Jaarboek van het Mijnwezen in Nederland Indie* (Annual journal of the mining department of the Dutch East Indies) was first published in 1872.[62] The incubation period of the "enlightened: scientific dream" gradually ended with more direct contact of science and politics: overseas explorers became themselves more as an advent of colonial bureaucrats than "missioned scientists". The romantic dreams of "Humboldians" such as Raffles and Von Siebold were shattered at the dawn of the institutionalization of "science".

7. Mines and Metal Production in Japan from the 1850's to the 1870's

In the political turmoil of the 1850's and the 1860's in Japan, various efforts were dedicated to self-protection. The visit of Perry to Japan in 1851 made a horrifying impact on the Japanese, leading to strong moves to build up an infrastructure to make a strong nation. Industrial development in Japan was largely restricted in comparison with Europe. However, the catching-up process displayed by Japan was remarkable. In Europe, Bessemer invented a new type of furnace in 1855, a year considered to mark the transition from the age of so-called "iron and coal" to that of "steel".[63] On the Japanese side, also in the year 1855, a reverbatory furnace in Mito was established, and two years later in Kamaishi, a Western type reverbatory furnace (using charcoal) was successful in smelting iron. This production was realized only after a long trial and error process in various feudal domains, such as Saga and Izu, where local officials merely based their attempts on the Dutch work, Huguenin's *Het Gietwezen in 's Rijks IJzer-Geschutgieterij te Luik* (Smelting in the National Iron Refinery in Liege) (1826). These technical attempts were extensively studied by Ohashi and Nakaoka, in which they demonstrated the intricate process of incorporating imported techniques

60 For the exploration of petroleum in the Dutch East Indies and its surroundings, see E. B. Wolfenden *Sources of Geological Information for S. E. Asia, Geological Society Miscellaneous Paper* 9 (1976).

61 The concept of the "Cathedral of science" is from S. Sheets-Pyenson *Cathedral of Science: The development of colonial natural history museum during the late nineteenth century* (1988).

62 For the institutionalisation of mining sciences in the Netherlands, see H. Stauffer 'The geology of the Netherlands Indies', in *Science and Scientists in the Netherlands Indies* (1945) 320-335; and C. L. van Nes 'De Delftse mijningenieur', in *Technische Hogeschool te Delft 1905-1955* (1955) 256-269.

63 For the transition in the industrial period from "iron and coal" to "steel", see D. Landes *The unbound Prometheus: technological change and industrial development in Western Europe from 1750 to the present* (1969).

into indigenous technical knowledge, namely the development of endogenous industrial technology in Japan.[64]

The supply of coal attracted attention in this period, primarily as fuel for war ships with steam engines, but also for iron smelting. Some coal mines in Japan, which had already been surveyed by Von Siebold in the 1820's, were worthy of attention. In Saga prefecture, the promotion of coal mining was led by the feudal lord Nabeshima Naomasa in the latter half of the 1850's. He adapted British coal mining techniques.[65] Also in the northern Kyushu area in 1855, the main vein in the Miike coal mine was opened and unprecedented modern shafts and galleries were sunk and dug. Investigation into coal veins in Hokkaido started in this period as well. Oshima Takato, who made a success of iron production by creating a blast furnace to produce pig iron (containing about 4% carbon), showed initiative in this field, too.[66] Oshima was appointed by the Tokugawa Government to explore coal mines in Hokkaido, and he carried out a field survey of the Kayanuma mine, applying a chemical analysis of ores in 1864. Oshima's contribution to the modernization of mining in Japan was outstanding in various respects. For instance, he introduced the use of explosives in mining and proposed administrative regulations similar to those still in effect today.

With regard to the transfer of science and technology, the situation drastically changed after the Meiji restoration in 1868. Apart from the few turbulent years in the beginning, the number of foreign engineers, so-called 'Oyatoi' (foreign experts), gradually increased and thanks to their contributions, especially in mining, the modernization process was accelerated.[67] It was, however, not a simple flow or diffusion of knowledge, but a painstaking process of assimilation by indigenous Japanese people of Western technology. In other words, foreign engineers were properly exploited for the sake of a "Japanese self-help take-off" to an independent industrial nation. The "Industrious Revolution", in Hayami's term, then successfully moved into the phase of "Industrial Revolution". This issue dose, though, require further discussion, as this absorption of Western technology occurred under very peculiar circumstances. It was deeply characterized by the military's desire to gain hegemony and supremacy over neighboring lands. This absolutely unacceptable aggression was, in fact, the most important reason for the "Japanese success". All in all, the Dutch commitment, at this stage, seemed to be diseased in its domination, and another framework is necessary for further discussion on this topic.

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64 Ohashi *Bakumatsu Meiji Seitetsushi* (1975).
Nakaoka 'Gijyutsushi no Kanten kera mita Nihon no Keiken', in *Kindai Nihon no Gijyutsu to Gijyutsu Seisaku* (1986) 3-106.

65 For exploration of the coal mines, see K. Ida, et al., eds. *Nihon Kagakugijyutsushi Taikei* 20 (1965).

66 For Oshima Takato, see Ohashi *Bakumatsu Meiji Seitetsushi* (1975).

67 For 'Oyatoi', see UNESCO Higashi Ajia Bunka Kenkyu Center *Shiryo Oyatoi Gaikokujin* (1975); and H. Takeuchi *Rainichi Seiyôjin Jinmei Jiten* (1983).

8. Concluding Remarks

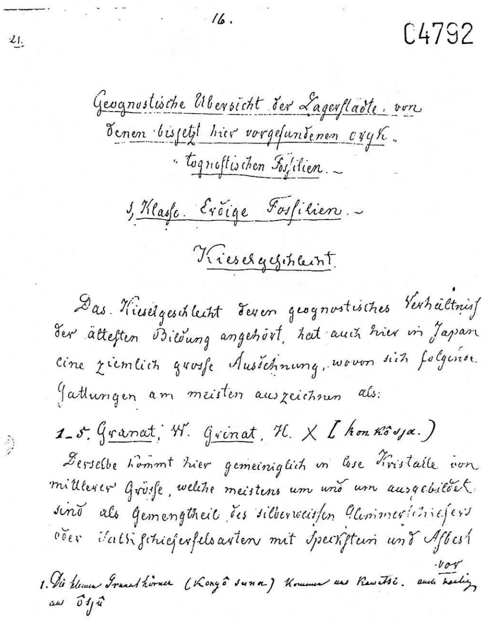
Having seen the outline of Dutch commitment to Asian mining resources and Japanese development of geological sciences as a sort of by-product of this, some historical conjuncture can be pointed out. According to Pyenson, the Dutch overseas empire had a most systematic character.[68] In the light of Pyenson's remark, it can be said that the Japanese took advantage of the infiltration of scientific curiosity. A resonance between the two, the Dutch colonial scientists and the Japanese Rangaku scholars, seemed to be amplified in this specific context.

Yet, generalization might not be the historian's primary job. During the period of the establishment of monetary independence from neighboring Asian economic systems, as was argued by Kawakatsu, techno-scientific pursuits succeeded in providing instruments for the later survival of independent Japanese monetary power. The seemingly sudden upraise of Japan as a modern industrial nation began much earlier than the Meiji Restoration with a trickling-down of Dutch scientific material. It was, however, not a simple diffusion process as the "Whiggish" triumphant march of "scientific rationality", but a phenomenon which took place within the politically and economically designed plot of colonial sciences.

68 L. Pyenson 'Pure learning and political economy: science and European expansion in the age of imperialism', in *New Trends in the History of Science* (1989) 209-278.

Figure 1. Copies of manuscripts on Japanese geology and mineralogy kept in Ruhr University.

a. Title page for geognotic observation (descriptive geology).
b. Manuscript on survey of copper.
c. Manuscript on a particular copper ore.


16.
C4792
21.

Geognostische Übersicht der Lagerstädte von denen bisjetzt hier vorgefundenen oryktognostischen Fossilien. ~

1, Klasse. Erdige Fossilien. ~

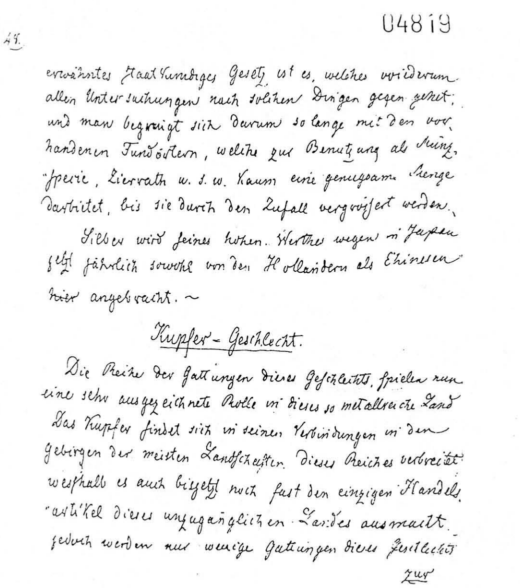
Kieselgeschlecht.

Das Kieselgeschlecht dessen geognostisches Verhältniß der ältesten Bildung angehört, hat auch hier in Japan eine ziemlich grosse Ausdehnung, wovon sich folgende Gattungen am meisten auszeichnen als:

1-5. Granat, W. Grenat, H. X [kon kôsja.)

Derselbe kommt hier gemeiniglich in lose Kristalle von mittlerer Grösse, welche meistens um und um ausgebildet sind als Gemengtheil des silberweissen Glimmerschiefers oder Talkschieferfelsarten mit Speckstein und Asbest vor

1. Die kleinen Granatkörner (Kongô suna) kommen aus Kawatsi. auch häufig aus Ôsjû

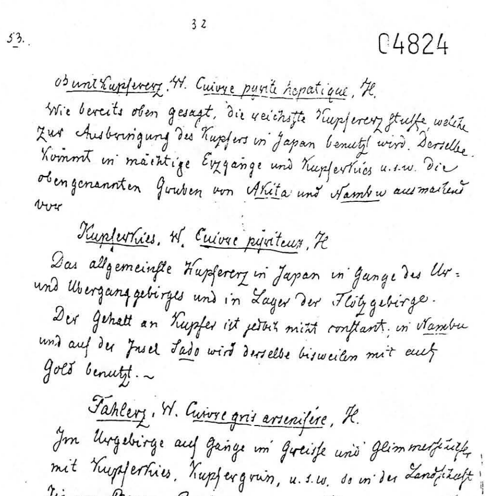

48.
C4819

erwähntes Staatkundiges Gesetz ist es, welches wiederum allen Untersuchungen nach solchen Dingen gegen geht; und man begnügt sich darum so lange mit den vorhandenen Fundörtern, welche zur Benutzung als Münzsperie, Zierrath u. s. w. kaum eine genugsame Menge darbietet, bis sie durch den Zufall vergrössert werden.

Silber wird seines hohen Werthes wegen in Japan selbst jährlich sowohl von den Holländern als Chinesen hier angebracht. ~

Kupfer-Geschlecht.

Die Reihe der Gattungen dieses Geschlechts, spielen nun eine sehr ausgezeichnete Rolle in dieses so metallreiche Land. Das Kupfer findet sich in seinen Verbindungen in den Gebirgen der meisten Landschaften dieses Reiches verbreitet, weshalb es auch bisjetzt noch fast den einzigen Handelsartikel dieses unzugänglichen Landes ausmacht. Jedoch werden nur wenige Gattungen dieses Geschlechts zur


32
53.
C4824

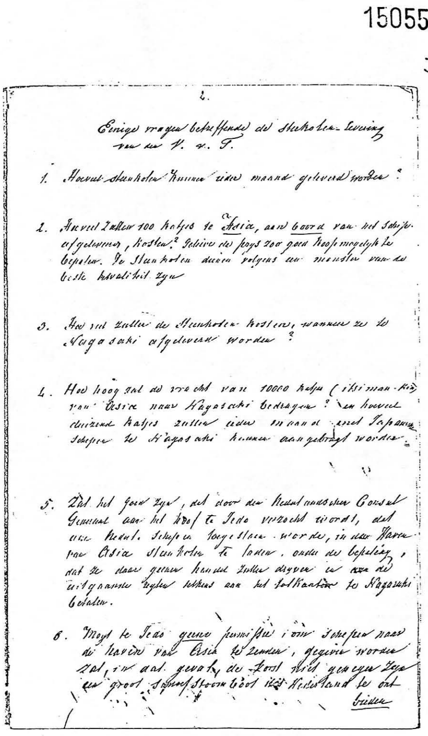
Buntkupfererz. W. Cuivre pyrite hepatique, H.
Wie bereits oben gesagt, die reichste Kupfererzstufe welche zur Ausbringung des Kupfers in Japan benutzt wird. Derselbe kommt in mächtige Erzgänge und Kupferkies u.s.w. die obengenannten Gruben von Akita und Nambu ausmachend vor

Kupferkies. W. Cuivre pyriteux, H.
Das allgemeinste Kupfererz in Japan in Gänge des Ur- und Übergangsgebirges und in Lager der Flötzgebirge.
Der Gehalt an Kupfer ist jedoch nicht constant; in Nambu und auf der Insel Sado wird derselbe bisweilen mit auf Gold benutzt. ~

Fahlerz, W. Cuivre gris arsenifère, H.
Im Urgebirge auf Gänge im Gneisse und Glimmerschiefer mit Kupferkies, Kupfergrün, u.s.w. so in der Landschaft Izu am Berge Bujisan; auch wird dasselbe seines beständigen Silbergehaltes wegen immer damit darauf benutzt. ~

Kupferlasur.

Figure 2. Copies of manuscripts on Japanese coal mines.
a. and b. Questionnaire by Von Siebold.


15055

37

2.

Enige vragen betreffende de Steenkolen-levering van [illegible]

1. Hoeveel steenkolen kunnen iedere maand geleverd worden?

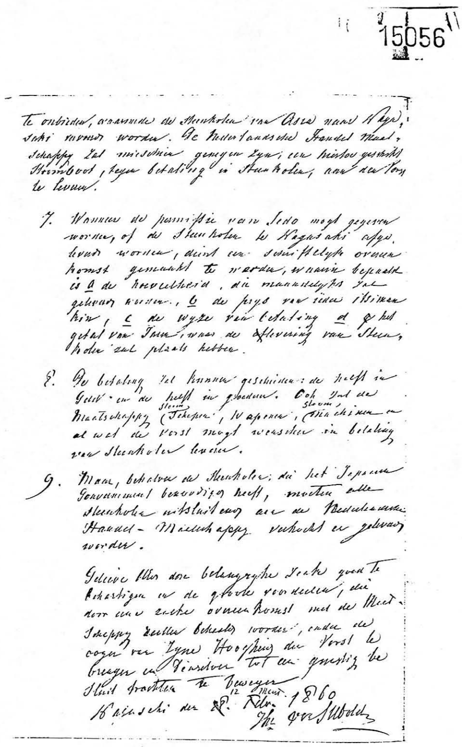
2. Hoeveel zullen 100 katjes te Assia, aan boord van het schip afgeleverd, kosten? Gelieve de prys zoo goed hoofs mogelyk te bepalen. De Steenkolen dienen volgens een monster van de beste kwaliteit zyn.

3. Hoe veel zullen de Steenkolen kosten, wanneer ze te Nagasaki afgeleverd worden?

4. Hoe hoog zal de vracht van 10000 katjes (itsiman-kin) van Assia naar Nagasaki bedragen? en hoeveel duizend katjes zullen iedere maand met Japansche schepen te Nagasaki kunnen aangebragt worden.

5. Zal het goed zyn, dat door den Nederlandschen Consul Generaal aan het Hof te Jedo verzocht wordt, dat aan Nederl. schepen toegestaan worde, in den Haven van Assia steenkolen te laden, onder de bepaling, dat ze daar geenen handel zullen dryven en de uitgaande regten [illegible] aan het tolkantoor te Nagasaki betalen.

6. Mogt te Jedo geene permissie om schepen naar de haven van Assia te zenden, gegeven worden zal, in dat geval, de Vorst niet genegen zyn een groot Schroefstoomboot uit Nederland te ontbieden


15056

te ontbieden, waarmede de Steenkolen van Assia naar Nagasaki vervoerd worden. De Nederlandsche Handel Maatschappy zal misschien genegen zyn, een hiertoe geschikt Stoomboot, tegen betaling in Steenkolen, aan den Vorst te leveren.

7. Wanneer de permissie van Jedo mogt gegeven worden, of de Steenkolen te Nagasaki afgeleverd worden, dient een schriftelyke overeenkomst gemaakt te worden, waarin bepaald is a de hoeveelheid, die maandelyks zal geleverd worden, b de prys van iedere itsiman kin, c de wyze van betaling d het getal van Jaren, waar de aflevering van Steenkolen zal plaats hebben.

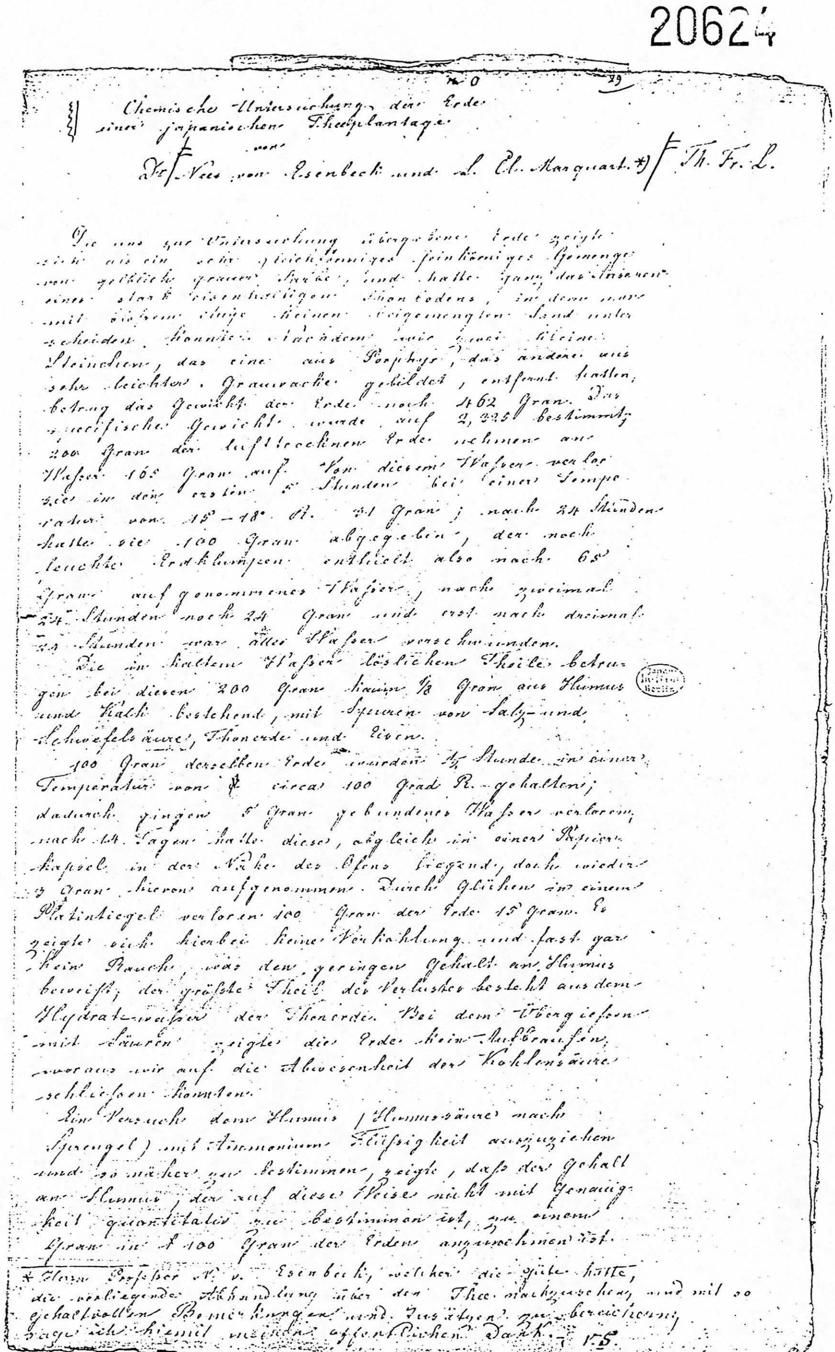
8. De betaling zal kunnen geschieden: de helft in Geld en de helft in goederen. Ook zal de Maatschappy (Stoom Schepen, Wapenen, Stoom Machinen en al wat de Vorst mogt wenschen in betaling van Steenkolen leveren.

9. Maar, behalven de Steenkolen, die het Japansche Gouvernement benoodigd heeft, moeten alle steenkolen uitsluitend aan de Nederlandsche Handel-Maatschappy verkocht en geleverd worden.

Gelieve [illegible] deze belangryke zaak goed te behartigen en de groote voordeelen, die door eene zulke overeenkomst met de Maatschappy zullen behaald worden, onder de oogen van Zyne Hoogheid den Vorst te brengen en [illegible] tot een gunstig besluit trachten te bewegen

Nagasaki den 12 Maart 1860
Ph. von Siebold

Figure 3. Copy of manuscript on chemical analysis of soil from a Japanese tea plantation. Carried out by Dr. Nees von Eisenbeck et al., kept by Von Siebold.


20624

Chemische Untersuchung der Erde einer japanischen Theeplantage von Dr. Nees von Esenbeck und Dr. Cl. Marquart.*) Th. Fr. L.

Die uns zur Untersuchung übergebene Erde zeigte sich als ein sehr gleichkörniges feinkörniges Gemenge von gelblich grauer Farbe, und hatte ganz das Ansehen eines stark eisenhaltigen Thonbodens, in dem man mit bloßem Auge keinen beigemengten Sand unterscheiden konnte. Nachdem wir zwei kleine Steinchen, das eine aus Porphyr, das andere aus sehr leichter Grauwacke gebildet, entfernt hatten, betrug das Gewicht der Erde noch 462 Gran. Das specifische Gewicht wurde auf 2,325 bestimmt. 200 Gran der lufttrockenen Erde nehmen an Wasser 165 Gran auf. Von diesem Wasser verlor sie in den ersten 5 Stunden bei einer Temperatur von 15°–18° R. 31 Gran; nach 24 Stunden hatte sie 100 Gran abgegeben, der noch feuchte Erdklumpen enthielt also noch 65 Gran aufgenommenes Wasser; nach zweimal 24 Stunden noch 24 Gran und erst nach dreimal 24 Stunden war alles Wasser verschwunden.

Die im kalten Wasser löslichen Theile betrugen bei diesen 200 Gran kaum 1/3 Gran aus Humus und Kalk bestehend, mit Spuren von Salz- und Schwefelsäure, Thonerde und Eisen.

100 Gran derselben Erde wurden 1/2 Stunde in einer Temperatur von circa 100 Grad R. gehalten; dadurch gingen 5 Gran gebundenes Wasser verloren; nach 14 Tagen hatte diese, obgleich in einer Papierkapsel in der Nähe des Ofens liegend, doch wieder 3 Gran hievon aufgenommen. Durch Glühen im einem Platintiegel verloren 100 Gran der Erde 15 Gran. Es zeigte sich hiebei keine Verkohlung und fast gar kein Rauch, was den geringen Gehalt an Humus beweißt; der größte Theil des Verlustes besteht aus dem Hydratwasser der Thonerde. Bei dem Übergießen mit Säuren zeigte die Erde kein Aufbrausen, woraus wir auf die Abwesenheit der Kohlensäure schließen konnten.

Ein Versuch dem Humus (Humussäure nach Sprengel) mit Ammonium Flüssigkeit auszuziehen und so näher zu bestimmen, zeigte, daß der Gehalt an Humus, der auf diese Weise nicht mit Genauigkeit quantitativ zu bestimmen ist, zu einem Gran in 100 Gran der Erde anzunehmen ist.

* Herrn Professor N. v. Esenbeck, welcher die Güte hatte, die vorliegende Abhandlung über den Thee nachzusehen, und mit so gehaltvollen Bemerkungen und Zusätzen zu bereichern, sage ich hiemit meinen öffentlichen Dank. v. S.

Figure 4. Copies from record of the "Red-haired people" visit to Sumitomo.

a. Names of Siebold (Shiifuruto) and Bürger (Birugeru) are seen.
b. Record of souvenirs: Item: *Kodô Zuroku*; Item: Sample Box of Copper Ores (Hakusekibako).

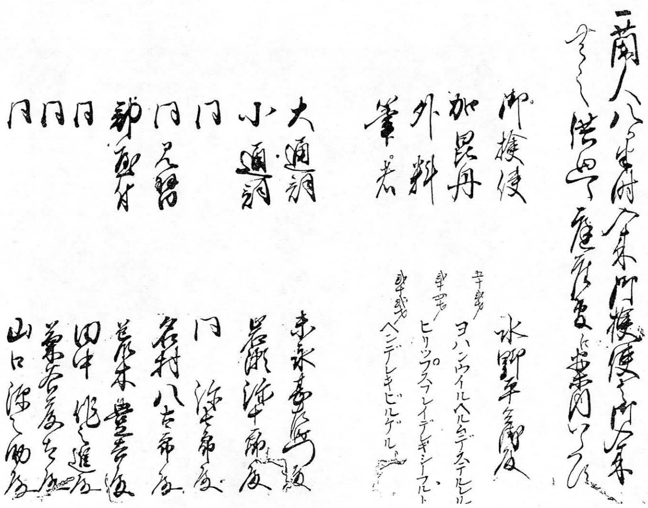


Figure 5. Samples from Von Siebold collection in the Rijksmuseum van Geologie en Mineralogie, Leiden, the Netherlands.

a. Sample box for copper ore. A stick of copper is included.
b. A sample, with card attached and description in German.
c. As above, cards in German and French with German and French names written by Bürger.

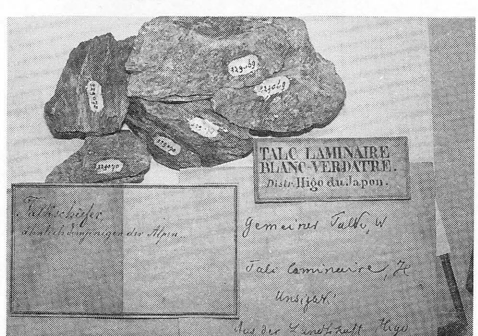
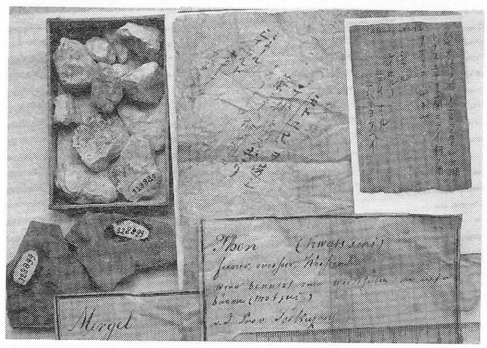
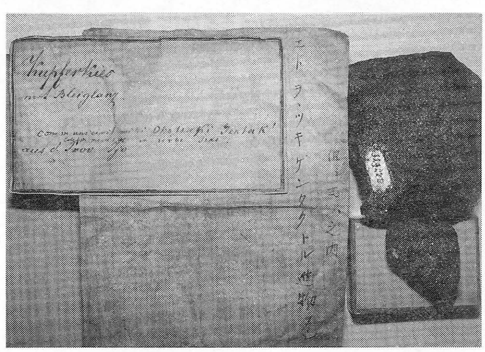


Figure 5. Samples from Von Siebold collection in the Rijksmuseum van Geologie en Mineralogie, Leiden, the Netherlands.

d. Cards written by Bürger. Nomenclature by Werner in German (suffixed by capital W) and bi- or trinary nomenclature by Hauy in French (suffixed by capital H.), with sample locality.

e. & f. Samples with Japanese description. These were probably given to Von Siebold or Bürger by their Japanese informants.





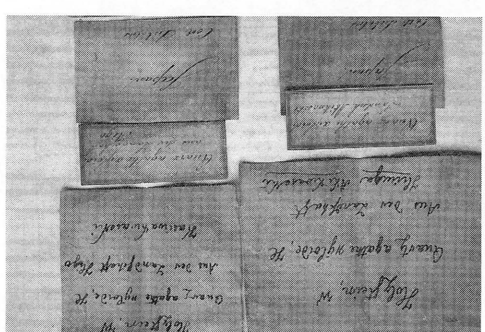


Figure 6. Copies from *Kodô Zuroku,* a version kept in the Netherlands (Registration No. 1-4635, Rijksmuseum voor Volkenkunde, Leiden. Bibliothéque Jose by L. Serruries, No. 901.).

a. Leaf 4b. b. Leaf 8a. c. Leaf 13b.

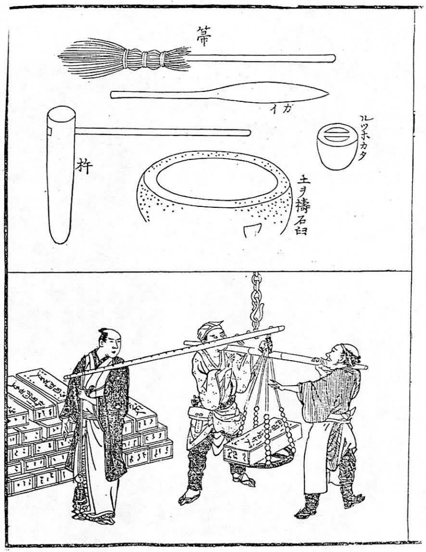


Figure 7. Copies of Bürger's article on Japanese copper.

a. Title page of the *Transaction of Batavian Society for Arts and Sciences*.
b. Title and the first page of Bürger's article.

BESCHRIJVING

DER

JAPANSCHE KOPERMIJNEN

EN DER

BEREIDING VAN HET KOPER;

DOOR

H. BURGER, PHIL. DOCT.

BELAST MET HET NATUURKUNDIG ONDERZOEK

OP

JAPAN.

BESCHRIJVING

DER

JAPANSCHE KOPERMIJNEN

EN DER

BEREIDING VAN HET KOPER.

De Schrijver dezes, op zijne reis naar Jedo in het jaar 1826, getracht hebbende, zoo wel door eigene waarneming in Oosaka en elders, als uit berigten van deskundigen, eenige bijzonderheden aangaande de Japansche kopermijnen, en de smelting en verdere bereiding van het koper te verzamelen, heeft geoordeeld, dat de tegenwoordige beknopte mededeeling van hetgeen omtrent dit onderwerp ter zijner kennis is gekomen, welligt niet ongevallig zoude zijn; hebbende hij daarbij tevens, tot meerdere volledigheid, gebruik gemaakt van een Japansch werkje, getiteld: *Ko-Do-Su-Rok* of *Afbeeldingen van de bewerking van het koper in Japan.*

De mijnbouw wordt in Japan niet naar een volledig wetenschappelijk stelsel of naar eene eigenlijke theorie, maar meestal enkel practisch, naar zekere, bloot door ervaring verkregene regelen, uitgeoefend. De opdelving van metalen, als goud, zilver, koper, enz., gaat in

A dat

Figure 8. A copy from *Kodô Zuroku*. Moulding of copper by water.