FROM SECRET KNOWLEDGE TO MASS PRODUCTION:

THE WET COPPER INDUSTRY OF SONG CHINA (960-1279)

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To my son

Hermann

who was born during the writing of this thesis

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Alexander Jost

Abstracts

English

"Wet copper" refers to refined copper, which is obtained from cupriferous substances by means of solution in water and precipitation on iron (hydrometallurgical methods) rather than by a conventional ore melting process (pyrometallurgical methods).

Knowledge about certain parts of this method already existed for many centuries mainly in the secret alchemist literature of China, when towards the end of the 11th century the Song state decided to use wet copper for its coinage. In numerous places in south-east China, large facilities employing tens of thousands of workers and producing more than 1 000 tons of copper annually were established. While during the beginning of the 12th century, still most of China's copper was obtained with conventional methods, ore deposits soon became exhausted and production numbers declined rapidly. Already by the second half of the 12th century, wet copper accounted for the lion's share of the urgently needed mint metal and developed into one of the state's most essential industries.

After the Mongol conquests, many parts of the complex system of state-owned industries in China fell into disarray and in particular mint metal production enjoyed no priority anymore because the monetary system of the following Yuan dynasty chiefly relied on paper money. When in the 16th century in Europe the first sources mentioned the

appearance of wet copper, in China hardly anything was known about it anymore. Only by the end of the 19th century, facilities operated by the Japanese can be found in Taiwan and only during the second half of the 20th century in Mainland China.

In the central focus of this thesis are issues like the circumstances leading to innovation and large-scale application of knowledge about wet copper, the technological details of different hydrometallurgical methods, the administrative integration of the state institutions in charge of wet copper production and the way they managed the operation of wet copper facilities, the correlations between the quantitative developments of wet copper production and the monetary policy of the Song state as well as the attempts to understand and explain metallurgical processes by contemporaries. Beyond this, the decline of wet copper production at the end of the Song period and its development in other world regions as well as in modern China are analysed.

As an outstandingly important source for the understanding and integration of questions related to copper production and minting in Song China, a complete annotated translation of the "Rhapsody of the Great Smelting" (*Daye fu* 大冶賦) is attached to this thesis.

Deutsch

Der Begriff „wet copper“ oder „Nasskupfer bezieht sich auf Reinkupfer, welches aus kupferhaltigen Substanzen durch Lösung in Wasser und Ausfällung auf Eisen (hydrometallurgische Methoden) anstelle von konventionellen Schmelzprozessen (pyrometallurgische Methoden) gewonnen wird.

Als gegen Ende des 11. Jahrhunderts der Song-Staat entschied, Nasskupfer als Münzmetall zu nutzen, waren zumindest Teile des dafür nötigen Wissens bereits seit Jahrhunderten zumeist in geheimen alchemistischen Schriften vorhanden. An zahlreichen Orten im Südosten Chinas wurden große Anlagen eingerichtet, die zehntausende Arbeiter beschäftigten und mehr als 1 000 Tonnen Kupfer jährlich produzieren konnten. Während noch zu Beginn des 12. Jahrhunderst der großteil des Chinesischen Kupfers mit konventionellen Methoden gewonnen wurde, gingen die Produktionszahlen bald darauf rapide zurück, weil viele der Lagerstätten erschöpft waren. So machte Nasskupfer bereits während der zweiten Hälfte des 12. Jahrhunderst den Großteil des dringend benötigten Münzmetalls aus und seine Herstellung wurde damit zu einem der wichtigsten Gewerbezweige für den Staat.

Nach der Eroberung Chinas durch die Mongolen gerieten viele Teile des komplexen Systems der staatseigenen Produktionsstätten in Unordnung und besonders die Gewinnung von Münzmetallen genoss keine hohe Priorität mehr, weil das Geldsystem der nachfolgenden Yuan-Dynastie hauptsächlich auf Papiergeld ausgelegt war. Als im 16. Jahrhundert erste Quellen in Europa auftauchten, die die Existenz von

Nasskupfer belegen, war die Technik in China bereits sehr weit gehend in Vergesssenheit greaten. Erst gegen Ende des 19. Jahrhunderts finden sich Anlagen, die auf Taiwan von den Japanern betrieben wurden und erst in der zweiten Hälfte des 20. Jahrhunderts auf dem Festland.

Das Hauptaugenmerk dieser Arbeit liegt auf Themen wie den Umständen, die zu Innovation und großangelegter Anwendung von des bestehenden Wissens über Nasskupfer führten, die technischen Details der verschiedenen hydrometallurgischen Methoden, die administrative Einbindung der staatlichen Instutionen, in deren Aufgabenbereich die Produktion von Nasskupfer fiel sowie deren Umgang mit Fragen des Betriebs der Anlagen, dem Zusammenhang zwischen quantitativer Entwicklung der Nasskupferproduktion und Geldpolitik oder die zeitgenössischen Bestrebungen, die Hintergründe metallurgische Phänomene und Prozesse zu verstehen. Darüber hinaus werden auch der Niedergang der Nasskupfergewinnung zum Ende der Songzeit und deren Entwicklung in anderen Weltregionen sowie im modernen China untersucht.

Da es seine Quelle von herausragender Bedeutung für das Verständnis des Themas sowie dessen Integration in den Kontext des songzeitlichen Münzwesens darstellt, ist eine vollständige annotierte Übersetzung der „Rhapsodie vom Großen Schmelzen“ (Daye fu 大冶賦) dieser Arbeit beigefügt.

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Nec Venus oranti – neque enim dea mollior ulla est –
Rustica Gradivo difficilisve fuit.
Ah, quoties lasciva pedes risisse mariti
Dicitur et duras igne vel arte manus!

Ovid, Ars Amatoria II, 561.

I) Introduction

In the scholarly discourse about the scope of economic development during the Song period (960-1276), a time labelled as the one which "saw the greatest flowering of indigenous Chinese science" [1] and the "beginning of 'modern' China"[2], metal production numbers play a crucial role. Not only the output of iron and coal has received much attention, because it provides a very suitable *tertium comparationis* with Britain during the Industrial Revolution,[3] also copper gives very interesting instance for similar reasons but also due to its very close relation to coinage and thus monetary history. The annual output of copper during the Song period in its best years reached up to 13 000 tons – more than the c. 10 000 tons the whole world produced in 1800.[4] What has received much less attention is the question, how exactly these enormous amounts of copper were produced. When it comes to the investigation of this question, a very particular technological innovation meets the eye, which usually appears in contemporary Chinese sources appears under the name of "gall copper" (*dantong* 膽銅). During the first half of the 12th century, only several decades after its first appearance, already far more than 1 000 tons of "gall copper" were produced, in later years, when output numbers

1 Needham (1956), p. 493.

2 Twitchett (1979), p. 8; Miyakawa (1955) explaining and refining the famous hypothesis by Naito Torajiro.

3 Hartwell (1962), Vries (2003).

4 Vogel & Theisen-Vogel (1991), p. 12.

had declined severely, it even accounted for up to 80 per cent of the overall copper production of China.

"Gall copper" or "wet copper" refers to refined copper, which is obtained from cupriferous substances by means of solution in water and precipitation on iron (hydrometallurgical methods) rather than by a conventional ore melting process (pyrometallurgical methods).[5] Wet copper methods allowed the recovery of otherwise unusable deposits and resources, spared miners the costly and laborious excavation underground and was extremely fuel-saving. In China, they began to be employed on a large scale around the end of the 11th century and almost completely vanished again after the end of the Song period. In other parts of the world, only four to five centuries later, indications of their use can be found and it may have taken until way into the 20th century, until similar production figures as in Song China could be reached.

In the central focus of this thesis are issues like the circumstances leading to innovation and large-scale application of knowledge about wet copper, the technological details of different hydrometallurgical methods, the administrative integration of the state institutions in charge of wet copper production and the way they managed the operation of wet copper facilities, the correlations between the quantitative developments of wet copper production and the monetary policy of the Song state as well as the attempts to understand and explain metallurgical processes by contemporaries. Beyond this, the decline of wet copper production at the end of the Song period and its development in other world regions as well as in modern China are analysed.

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[5] For a more detailed explanation of the underlying process and its advantages, see chapter II.1 of this thesis.

1) State of the Field

No comprehensive study about the history of wet copper has been written so far, neither covering the situation in China, nor worldwide. Publications in Chinese language are fairly numerous but each of them very limited in their extent as brief journal articles treating the topic either rather superficially or focusing on one very particular aspect of the field. After earliest beginnings in the 1950s e.g. by Wu Zizhen 吴子振[6], the ground to these studies was, however, largely prepared by the works of Guo Zhengyi 郭正誼[7] in the early 1980s. In the 1990s, Hua Jueming 华觉明 and You Zhanhong 游战洪[8] contributed to a deepened understanding through their valuable work on the "Rhapsody of the Great Smelting" (*Daye fu* 大冶賦), a source of outstanding importance not only on wet copper but also on other fields of mining, minting and metallurgy, for which an annotated English translation is included in this thesis. A more recent and quite detailed article on the situation at the Censhui 岑水 mine has furthermore been published by Song Huiqun 宋會群[9] in 2005. For the events around the earliest establishment of wet copper production in China, the research carried out by Chen Dingrong 陳定榮[10], Sun Yigang

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6 Wu Zizhen (1958).

7 Guo Zhengyi (1981, 1983).

8 Hua Jueming & You Zhanhong (1997a,b).

9 Song Huiqun (2005).

10 Chen Dingrong (1991).

孫以剛[11] and Sun Chengping 孫承平[12] on the Zhang family in Jiadao are important. The larger picture of the relations between the state and the mineral industries in Song China cannot be understood without the extensive publication activities of Wang Lingling 王菱菱,[13] for the particular role of coinage and the mints, the classical work of Peng Xinwei 彭信威[14] and the more recent books of Wang Shengduo 汪圣鐸[15] are indispensable.

In western languages, the earliest short explanation of the process goes back to Joseph Needham[16], who also coined the term "wet copper" used to address the respective phenomenon in this thesis. A more detailed account was given in 1986 by Lung Tshun-ni[17], at that time director of the modern wet copper facilities in Jinguashi 金瓜石, Taiwan. This study was further developed by Peter Golas, first into an article[18] and later into a chapter of his Needham volume on mining.[19] As a part of his research on wet copper, Golas as well launched the project of translating the *Daye fu*,

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11 Sun Yigang (2003).

12 Sun Chengping (2003, 2006).

13 Wang Lingling (2005a) et al.

14 Peng Xinwei (1965, 1966).

15 Wang Shengduo (2003, 2004).

16 Needham (1980), p.204.

17 Lung Tshun-ni (1986).

18 Golas (1995).

19 Golas (1999).

which he kindly passed to the author, so that this translation is now included into this thesis.

2) Methods and Sources

The most important method to approach the topic is the evaluation of historical sources. Among the consulted sources, three are of particular prominence.

This is firstly the "Rhapsody of the Great Smelting" (*Daye fu* 大冶賦), a prose poem written in 1210 by Hong Zikui 洪咨夔.[20] This elaborate piece of literature is a comprehensive description of the production of precious- and semi-precious metals as well as coins in Song China in their social, economic and administrative context and thus of highest relevance for close to all the chapters of this thesis. So far, the *Daye fu* has only been considered to a very limited extent within the study of mining and metallurgy of the Song period. Secondly, the "Book of Yan[shan]" (*Yan shu* 鉛書), a collection of local sources from Yanshan compiled in 1618 by Ke Zhongjiong 柯仲炯.[21] This book contains very rich information on the practical application of wet copper production in Yanshan and has not been reprinted since, only one copy is preserved in the library of Peking University. Hence so far no related research has consulted this work at all making the information derived from it entirely new to the field. The third one is the extensive "Song dynasty manuscript compendium" (*Song huiyao jigao* 宋會要輯稿), which is surely the most used and most important

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[20] PZWJ / DYF.

[21] YS.

source concerning questions of administration in Song China. Although information from the *Song huiyao jigao* has already been used widely to understand the history of wet copper. Many entries, however, have been considered in this thesis for the first time.

Besides these core sources, numerous other texts are consulted to complement the information obtained through them. These sources fall into as different categories as local gazetteers (*difangzhi* 地方志)[22], Alchemist and Daoist writings (*daojia* 道家)[23], family books (*zongpu* 宗譜, *jiapu* 家譜)[24], Grave stele inscriptions (*muzhiming* 墓志銘)[25], private writings and collections (*wenji* 文集, *biji* 筆記)[26], pharmacopoeias (*bencao* 本草)[27] and many other miscellaneous types of texts. For the understanding of the *Daye fu*, a great number of classical writings of various types have been used. For the understanding of other aspects of mining as well as on the situation of wet copper outside of China, a great number of different types of sources in Greek, Latin, English, German and Arabic has been consulted.

Besides this classical method of historical study, field research has been undertaken containing two different types of activity: Firstly, it was investigated, if around those places which were important for wet copper

22 e.g. YSXZ, JXTZ, KJZ.

23 e.g. ZTDZ / DFJY, LHHDJ, SSLSF.

24 e.g. JDZSZP.

25 see e.g. Chen Dingrong (1991); Sun Yigang (2003); Sun Chengping (2003, 2006).

26 e.g. WASWJ, OYWJGWJ, MXBT.

27 e.g. BCGM, BCJJZ, CXZHJSZLBYBC.

production during the Song period, still remains of traditional metal production could be found,[28] or if similar ways of production were carried out until the present day.[29] Secondly, samples of vitriol water in different stages of a wet copper production process as well as of different types of vitriol earth were taken and analysed for their content in copper, iron and sulphur. From this field research, which was undertaken in the years 2012 and 2013, it was possible to gain a much clearer idea about the actual appearance of the described processes *in natura* as well as to obtain a somewhat clearer idea about the quantities and scopes discussed in this thesis.

[28] This was the case in Dexing, Shaoguan and Daye.

[29] This was the case in Yanshan.

II) Background

1) Wet Copper Technology

A) Description

The term "wet copper production" as applied in the frame of this thesis refers to any method of copper production involving a so-called replacement reaction, usually leading to a precipitation of copper molecules on iron. This process is represented by the following chemical equation:

$$\underset{(aq)}{CuSO_4} + \underset{(s)}{Fe} \rightarrow \underset{(s)}{Cu\downarrow} + \underset{(aq)}{FeSO_4}.$$

Aquatic copper sulphate solutions can appear naturally in any place where fluvial waters or rain waters seep through layers of copper sulphate bearing minerals or soils and are usually referred to as "vitriol waters". Besides, they can also intentionally be generated for instance by leaching out copper ore or copper bearing earths and sands, usually referred to as "vitriol earths". As soon as suitable copper sulphate solutions get in touch with iron, copper molecules start to precipitate on the iron surface while iron molecules begin to replace the copper molecules inside the copper sulphate solution thus turning it into an iron sulphate solution. The precipitated copper can be easily separated from the core of the iron object in the shape of copper mud, after drying of copper powder. While theoretically this copper powder would consist in pure copper, in reality due to a varying content of other residues, it usually needs to be smelted for further purification.

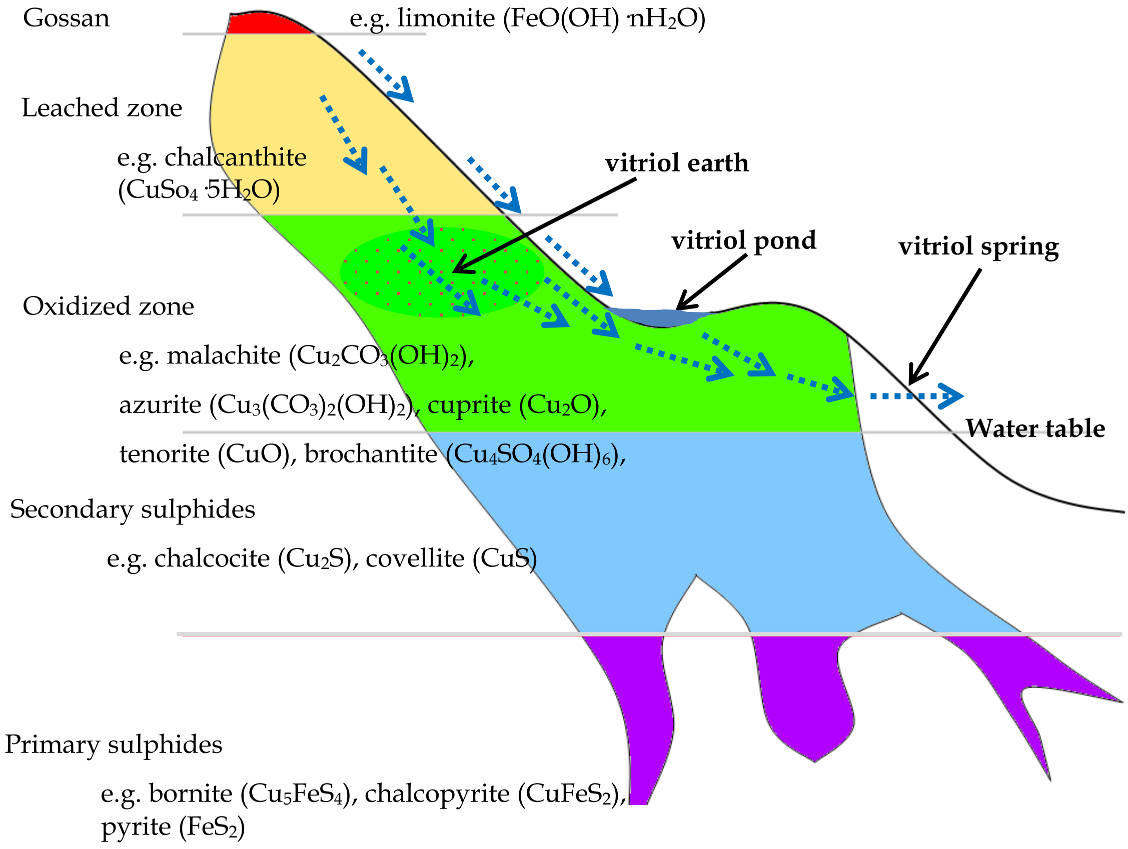

Fig. 1. Generation of vitriol water and vitriol earth in a typical copper deposit. Source: Designed by the author.[30]

[30] After examples by Golas (1999), p. 371, Lung (1986), p. 118 and Rosenfeld (1965), p.134).

Figure 1 illustrates the generation process of vitriol earths and waters as they appear naturally in the environs of hydrothermal copper and iron sulphide deposits, the most common structure of copper ore deposits worldwide.[31] The top of the deposit is formed by a so-called "gossan", a layer consisting in iron ores like limonite, which was created by the complete oxidation of the original primary copper iron sulphide deposit due to the actions of air, water and ferric salts.

The following layers are largely leached out of their copper content as well, while on deeper levels, close to the water table copper ores enriched by the copper sulphides from the top layers appear and form rich so-called "secondary deposits" consisting in carbonate, oxide and sulphate ores. In this zone, the surrounding earth is enriched by copper as well forming the above mentioned vitriol earths. It is furthermore most suitable for the generation of highly concentrated vitriol waters, too. In the layers below the water table, oxidation and secondary enrichment play a smaller role; they consist mainly of primary deposits.

Based on this, the entire process of wet copper production from its appearance in secondary ore deposits until its casting for instance in a mint for copper cash coins is displayed by Lung Tshun-ni in the following flow chart:

[31] For a complete description of these processes, see Golas (1999), p. 370.

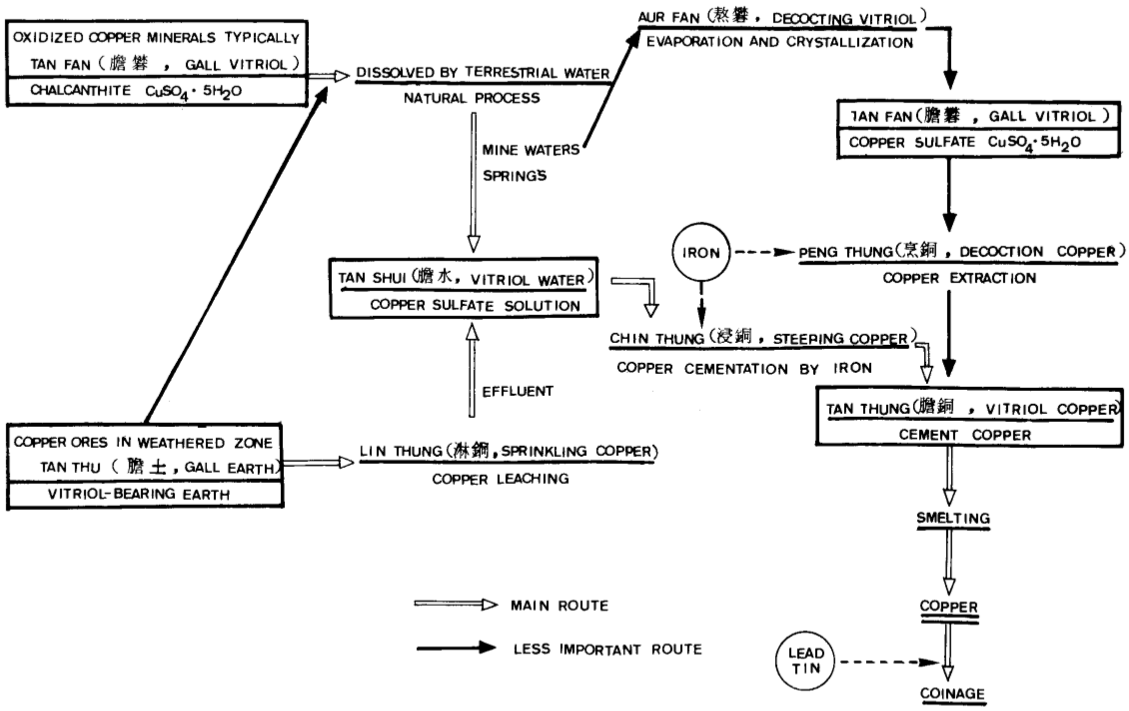

Fig 2. Flow chart of the entire process of wet copper production as applied in China for the purpose of coin casting, after Lung (1986), p.123.

B) Terms and Definitions

Studying the application of this process in the context of pre-modern China requires the handling of at least two entirely different sets of terminologies which originate from very different views on nature and the world in general as well as on the foundations of mining and metallurgy in particular. Moreover, modern Chinese and ancient European expressions in use for one thing or another carry a potential for additional complication. For the choice of terms utilised in this thesis, it is impossible to limit oneself to the use of only modern-Western or only traditional Chinese terminology, because ignoring the former would make it impossible to follow the described phenomena from a scientific perspective, ignoring the latter would pose difficulties to an accurate discussion of historical sources. It was thus in some cases necessary to make arbitrary, though not ungrounded decisions for one term or another, in other cases, no single term was chosen and several expressions are used alongside each other.

The most crucial term is the one referring to the method under consideration itself, which thus deserves to be treated more detailed in this place. In Chinese sources of the Song period, *dantong* 膽銅 meaning "gall copper", respectively *dantong fa* 膽銅法, "gall copper method" are most common. *Jintong* 浸銅, which can be translated as "copper steeping" or probably better "copper soaking" which usually refers to the use of the replacement reaction in natural vitriol waters not considering the leaching process (*lintong* 淋銅, lit. "copper sprinkling", here usually "copper leaching") was a popular term as well. Other expressions to be found in historical sources are *tietong* 鐵銅, "iron copper"[32] and *quantong* 泉銅, "well copper"[33]. In modern China, copper producers commonly refer to the method as *xi tong* 洗銅, "copper washing"[34], or *haimian tong* 海綿銅, "sponge copper"[35], while chemists prefer the expressions *jinxifa cai tong* 浸析法採銅, "copper exploitation through the method of soaking and separating"[36], *shuifa lian tong* 水法煉銅, "copper production through the

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32 BCGM / BCL *Jinshi* 金石 (metals and stones), chapter 8, item "red copper" (*chitong* 赤銅), Golas (1999), p. 373, Yang Gen (1980), p.2.

33 YS, chap. 7, p. 93b.

34 Yin Jian (2013).

35 This expression is at least commonly in use in present day Jiangxi, as the author has heard during his field research.

36 Wu Zizhen (1958).

water method", *shifa lian tong* 濕法煉銅, "copper production through the wet method" or *rongjin cai kuang* 溶浸採礦, "ore exploitation by dissolving and soaking"[37]. The latter three terms do not only refer to the traditional way of production but also to more recently developed methods including those using electrometallurgy or bacteria. In English and other Western languages, the expressions at hand are various as well: Golas choses the term "copper precipitation process"[38], while Needham had earlier given preference to the wider term "wet copper method"[39]. The English term "copper cementation" is in use as well though more popular in German Language as "Zementkupfer" or in Spanish as "cementación"[40]. In a wider scope, the process can be described as "Copper production with hydrometallurgical methods" as well, then of course explicitly referring to an entirely modern scientific category.

This thesis uses the term "wet copper". It is an existing term in English rather than a translation from Chinese, nonetheless it does not contradict with traditional Chinese concepts and would almost doubtlessly have been understood by the Chinese of the Song period as well. Furthermore it is not bulky to use due to its shortness and bears the authority of Joseph Needham. When primary sources are cited, however, it is attempted to choose a translation as close as possible to the original. The expressions "copper soaking" and "copper leaching" are used as well, but then each of them indicates a specific method of wet copper production.

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37 Rao Dunpu (1981).

38 Golas (1999) p.370 et al.

39 Needham (1980), p. 204.

40 Habashi (2005), p.16.

C) Advantages of Wet Copper Production

During the actual application of wet copper production methods, efficiency and thus success may vary greatly due to a large series of external factors, which are discussed in a special chapter from page 141 onward. Under sufficiently suitable conditions, however, it provides a number of advantages compared to conventional methods.

Firstly, it allows the exploitation of deposits, which can otherwise not be used for copper production, especially with traditional means. This would be the case for instance for technically inaccessible copper ore veins, which can be leached out by natural water flows, for vitriol water already extent at the surface or for ores or soil bearing copper sulphates in a concentration too low to be smelted economically.

Secondly, the copper content of the substance obtained as a precipitate on the surface of the iron chips is incomparably higher than the one of basically all copper ores which can be mined in larger amounts with conventional methods. Consequently, the demand of fuel for further refining of this "copper mud" is much lower than for the roasting and smelting of ores.

Thirdly, labour conditions of workers employed in wet copper production are much more favourable than in most stages of conventional copper production. Arduous, dangerous and unhealthy underground striking or haulage is not necessary, the most labour-intensive part of the process, the washing of the iron chips takes place aboveground and its difficulty can rather be compared to other tasks in household or agriculture.

Fourthly, little to no capital is necessary to begin with the operation of a basic wet copper production facility. Other than in the case of conventional mining and smelting, no long galleries need to be struck through dead rock, processing facilities, roasting kilns and large smelting furnaces are often obsolete as well or can be constructed much smaller.

2) The Role of Copper

The uses of copper throughout history in China as in any other metal-working civilisation of the world have been extremely various. This is for one reason due to the fact that copper together with gold was the earliest of all metals used by humans. The reason for this is, that native copper – just like native gold – is very easy to identify and after it is collected can be forged into any desired shape without difficulty.[41] The earliest evidence for the use of copper in China is today dated to the late fourth to the early third century BC.[42]

To the opposite of Gold however, copper was usually available in greater amounts, much harder and thus more stable to be applied for almost any kind of tools. This was of course the more true when bronze alloys with the addition of tin were used instead of pure copper. Even mining tools were made of bronze before the introduction of iron working (see Fig. 3).

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[41] Golas provides a more detailed discussion, if actually gold or copper was used earlier by Humans, see Golas (1999), p. 109.

[42] Linduff (1997), p. 306-418; Mei Jianjun (2000).

Fig. 3: Bronze axe, supposedly used for mining, Tonglüshan 銅綠山, Hubei Province, Spring and Autumn period (771-476 BC).[43]
Source: Hubei Provincial Museum, Wuhan; Photo taken by the author.

With this elevated position – beside gold – among the metals, copper already very early was considered a material of very high prestige. This first manifested itself in its use for the casting of ritual vessels partly used for the symbolic bestowal of power among the Chinese aristocracy during the Zhou period (1046-256 BC).[44] Later, probably since the 8th to 10th century BC on, copper became the material for the first coins, which as spade money (*bubi* 布幣) reflecting the shape of cloth slowly began to drive commodity monies and cowries out of circulation.[45]

In the following centuries, the shape of the copper objects used as currencies changed. Between 600 and 200 BC, knife money (*daobi* 刀幣)

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[43] For more information on the copper and bronze tools found at the Tonglüshan mine see e.g. Vogel (1982), p. 147ff.

[44] Falkenhausen (1999), p. 472.

[45] Hartill (2005), p. 5.

was widespread in various regions of China.[46] Only after the unification of China by the Qin Dynasty in 221 BC and during the following Han Period (206 BC-220 AD), monies imitating the shapes of tools and other objects disappeared and the round shape with a rectangular hole in the middle, which had already co-existed with those for several centuries became the classical shape of Chinese cash coins for two millennia to come.[47]

Although over this long period of time, alloys, sizes and production techniques all underwent significant changes, copper always remained the main constituent of these cash coins. The cash coins in turn, in spite of the appearance of numerous other currencies, remained the most important means of payment in daily life until around the end of the Qing Dynasty (1644-1911). It is thus through this function, that producing sufficient amounts of copper was at any period of Chinese history always crucial for upholding a functioning monetary system and thus a thriving economy. Accordingly, the most important use of copper – qualitatively as well as quantitatively – was the one as a mint metal. If this is true for the history of Chinese copper production as a whole, then even more for the period of the Song Dynasty (960-1279), which saw an enormous increase for the importance of monetary transactions in the Chinese economy and thus exponentially rising numbers of coin production.[48] To obtain this mint metal was the main motivation and driving force for the state and for educated circles to show and interest in mining technology and metal production at all and it is thus very closely related to this fact, that today

46 Hartill (2005), p.53.

47 Hartill (2005), p. 83.

48 see chapter II.3d of this thesis.

fairly rich sources about metal production in ancient China have survived at all. Despite this high priority to use copper as a mint metal, which at times developed into an exclusive monopoly of the state mints to use copper at all or even to a melting down of non-monetary copper objects in order to cast coins,[49] other uses of copper were important, too.

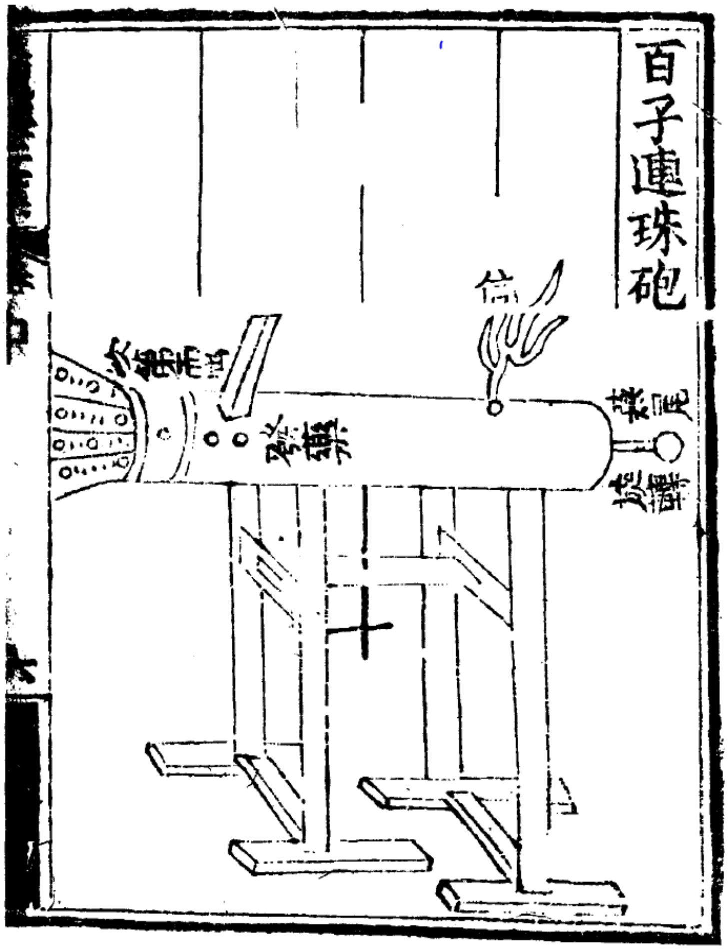

Fig. 4: Illustration of a "multiple bullets magazine eruptor" (*baizi lianzhu pao* 百子連珠炮) in the "Fire Dragon Classic" (*huolong jing* 火龍經) from the early Ming period (1403).
Source: Needham (1987), p.265)

[49] see e.g. King (1965), p. 51ff, Vogel (1983), p. 87ff.

This was especially from the perspective of the state, weaponry. In particular during the Song period, when gunpowder began to be applied in warfare, armies needed to be provided for instance with the new large eruptor canons called "multiple bullets magazine eruptor" (*baizi lianzhu pao* 百子連珠炮) made of cast bronze (see Fig. 4),[50] but also with the much smaller "fire lances" (*huoqiang* 火槍) or "fire tubes" (*huotong* 火桶), early versions of hand guns and flame throwers often made of bamboo but often also of bronze or brass.[51] In times of intensive warfare, a remarkable part of the copper otherwise destined for the use by the mints needed to thus be taken over by the military.

A very great consumer of copper can also be identified in temples and other religious establishments. For instance Buddha statues, images of all kinds of deities, incense burners, bells and various architectural elements were all made of copper or bronze. Because the existence of those objects was not of the same importance for crucial state functions, this often lead to conflicts when in times of copper scarcity the melting down of statues in temples was demanded to cast coins or cannons. The *Daye fu* also refers to this kind of situation and praises that if mines and wet copper production facilities work well and their copper can reach the mints,

> 蓋不待銷飛廉、鉦瞿曇而鐘官之用足。[52]
>
> "[…] there is no need to melt down statues of the Feilian or of Sakyamuni, since there is enough to be used by the Director of Minters."

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[50] Needham (1987), p.264.

[51] Needham (1987), p. 290.

[52] DYF, see chapter X.2o of this thesis.

Other uses for copper were either of less obvious importance or required much smaller amounts of the metal, such as the production of weighing pieces and measuring instruments, for which copper was preferably used because of its relatively high capability to resist changes through temperature or humidity, of mirrors, elegant tableware, and many other smaller objects more or less present in life.

Fig. 5: Thousand-handed Bodhisattva (*qianshou guanyin* 千手觀音) statue from the Northern Song Period in the Longxing 隆興 temple in Zhengding 正定, Hebei Province. The statue is 21.3 meters high.
Source: Anon. (2007).

3) Conventional Metal Production

Copper was usually produced from ores, which were obtained through underground mining activities, processed in different ways and finally purified by smelting. This production process was of course in many ways similar to the one of other metals and thus makes it necessary to give some attention to general characteristics of mining technology in Song China, in order to gain a better understanding about in which ways wet copper production was different from these conventional methods.[53]

A) Prospection

At the beginning of any successful mining activity stands prospection. This very complex but also very decisive part of metal production can be divided into three big fields of practice and knowledge: recognition of suitable ores, locating of ore deposits in the landscape and locating of veins and seams on the spot.

[53] These aspects are not discussed thoroughly within the frame of this thesis. The given statements generally relie on secondary literature, in particular on the excellent studies in this field, which are provided by Golas (1999), Wang Lingling (2005a et al.), Vogel & Theisen-Vogel (1992) and in parts also Peng Xinwei (1965) and Hartill (2005). Passages from the Daye fu and the Gazetteer of Longquan, which stands in a close relation to the former one, are incorporated to illustrate the situation with examples from the Song period.

Ores

Before any search for workable deposits can begin, it is inevitable that the prospector or miner knows what he is searching for, the most important instrument for this purpose is his visual judgement. He relies on his knowledge and experience concerning the appearances of useful minerals, which is often but not always characterized by a certain metallic sparkle of different kinds. The *Daye fu* lists some of these impressions:

> 烏膠綴，金星爍。薮花淡，丹砂渥。鼠結聚團，雞樵散泊，餈餌膏油，英潤濯濯。[54]
>
> Studded with dark, glue[-like spots] and with golden stars sparkling, like a light yellow flower or like dark red cinnabar, similar to mice forming a group when gathering, or similar to chicken dispersing when scared, resembling greasy and oily rice cakes, shining, glossy and bright.

From these short descriptions it can of course only be speculated, which types of copper ores the text intends to describe: "studded with dark, glue[-like spots] and with golden stars sparkling" could be a reference to various mixed rocks containing the mineral chalcopyrite ($CuFeS_2$). "Like dark red cinnabar" could refer to certain appearances of bornite ores (Cu_5FeS_4)[55] and the greasy and oily rice cakes may not actually represent copper ore but limonite, a very common iron ore, which often appears as a so-called "gossan", an iron outcrop in the already largely oxidised top zone of certain copper deposits (see Fig.1).

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[54] DYF, see chapter X.2j of this thesis.

[55] Okrusch & Matthes (2010), p. 62.

These visual qualities, which are discussed much more in depth by Golas,[56] must have been the first indicators attracting people's attention, before one could even start searching for suitable places to mine.

Fig. 6: Limonite ore from a gossan in Pfaffenreuth, Germany, which could be characterized as "resembling greasy and oily rice cakes."

Deposits

Once miners knew what appearances they had to look for, locations to obtain the respective minerals needed to be found. Their biggest helper with this endeavour were luck and coincidence, as can be seen from the fact, that in traditional China generally speaking the population density

[56] Golas (1999), p. 222ff.

was proportionally related to the density of discovered and exploited mineral deposits.[57] Accordingly, many curios and mysterious stories, often involving animals can be found, which explain, how a deposit was once discovered. The *Daye fu* includes some of them as well:

> 銅犇牛而流魄，銀走鹿而儲精。[58]
>
> […] copper [was found] by a galloping buffalo with a transient soul and silver [was found] by a running deer with a supernatural spirit.

This passage alludes to two stories explaining the discovery of outcrops to larger deposits. In Kuaiji 會稽, the modern Shaoxing in Zhejiang people chased a copper-coloured buffalo and by this discovered a copper deposit on the mountain,[59] in Dexing 德興 in Jiangxi a certain Zhang Meng 張蒙 during the Sui period (581-618) hunted a white deer and lost it but found a silver outcrop instead.[60] Similar phenomena can also be observed with Salt wells, which then often carry animal names.[61]

Although luck may have played a very important role, more systematic prospection did take place as well and certain rules and guidelines helpful for the identification of deposits were believed by miners, though not all of them must necessarily have been useful. One indicator for a possible location of a deposit was seen in the surrounding vegetation. On the one hand, a lack of vegetation was regarded as a sign,

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[57] Golas (1999), p.205.

[58] DYF, see chapter X.2e of this thesis.

[59] KJZ chapter. 9.

[60] JXTZ, chapter 109.

[61] Zhu Xia (2011), p. 39, 64.

that in this place mineral deposits could be found. The *Daye fu* refers to this observation as well:

> 巀嶭岑嶒，崴嵬嶢崅。[62]
>
> On the uneven and barren soil of high and steep mountains iridescent and colourful [outcrops appear].

The reason for this observation, which is also shared by Song Yingxing[63] may be threefold:

1. In places where no dense vegetation blocked the sight, it was easier to find outcrops of ore deposits.[64]
2. Vegetation may have been sparse at very steep mountain sides or in other specific landscape settings caused partly by the dislocation of soil layers. Such geological conditions may have exposed parts of deposits otherwise hidden in deeper layers of the earth.
3. This may be an *ex posteriori* observation in existing mining regions, where intensive woodcutting for the purpose of charcoal production and gallery construction may have caused soil erosion and as a consequence of this a lack of vegetation.

But not only barren soils could indicate the existence of deposits. There are certain plant species which are said to grow especially well on top of copper deposits, a phenomenon that has even defined their names such as the "Copper grass flower" (*tongcao hua* 銅草花) (elsholtzia splendens) or the "Patina flower" (*tongxiu hua* 銅臭花) (elsholtzia

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62 DYF, see chapter X.2j of this thesis.

63 TGKW, see Golas (1999), p.205.

64 Golas (1999), p.205.

argyi). Similar phenomena are also known for the vegetation around zinc, gold or uranium deposits.[65]

Another way to locate ore deposits, which in some cases is also explainable through modern geology, is the idea that certain minerals often appear associated with other types of rocks or minerals. The case of the gossan on top of a copper deposit may serve as one example for this. Other examples would be the association of gold and jade, gold and quartz or cinnabar and quartz.[66] These associations were in fact of greatest use for prospectors, though the explanation for them was often misleading in that way that they were usually understood in the context of images of organic growth of the ore veins in the nurturing soil of a certain rock or of mother-child relations between different minerals.[67]

Besides these methods, many other ideas existed, which were related to Fengshui, landscape forms, meteorological phenomena and other appearances, which cannot all be discussed here in detail.[68]

Veins

When a deposit was located through the observation of outcrops, excavating could begin but could also very soon find an end again. This was not necessarily the case because the deposit would already be exhausted, but because especially in those zones situated close to the

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[65] Golas (1999), p.219.

[66] Golas (1999), p. 217f.

[67] For more details on the topos of organic growth and other concepts of tradional Chinese understandings of metal, see chapter VII.1 of this thesis.

[68] For more information on these methods see Golas (1999), p.206ff.

surface of the earth, deposits can have very different shapes. Without awareness and experience, these different shapes could easily lead miners to give up on an actually large and promising deposit or to continue excavating into a superficial and unsuitable one. The *Daye fu* includes such observations as well:

> […] 山多衆樸，蜿蟺扶輿，鬱積磅礴，巀嶭岑嶝。 […] 礦紋異采，乍純遽駁，爊苗殊性，欲斷還絡。[69]
>
> […] the mountains contain a great variety of ores, which occurs in serpentines, rises spirally or accumulates to massive blocks. […] The grain of the ore is of different colours, sometimes pure but suddenly mixed. Scenting veinlets are of varying nature, sometimes break off, but are then connected again.

In its chapter about copper mining, the Gazetteer of Longquan (*longquan xianzhi* 龍泉縣志) from the Song period, which stands in a close temporal and local relation to the Daye fu[70], includes this topic as well and offers information comparable to the one in the *Daye fu* but with a somewhat higher level of detail:

> 五金之礦，生於山川重複高峰峻嶺之間。其發之初，唯於頑石中隱見礦脈，微如毫髮。有識礦者得之，鑿取烹試。其礦色樣不同，精麁亦異。[…]礦脈深淺不可測，有地面方發而遽絕者，有深入數丈而絕者，有甚微，久而方闊者，有礦脈中絕，而鑿取不已，復見興盛者，此名為過壁。有方采於此，忽然不現，而復發於尋丈之間者，謂之蝦蟇跳。大率坑匠採礦，如蟲蠹木，或深數丈，或數十丈，或數百丈。隨其淺深，斷絕方止。舊取礦攜尖鐵及鐵錘，竭力擊之，凡數十下僅得一片。[71]
>
> The ore of the five metals is generated in mountain areas between staggered high peaks and lofty mountain ranges. Its appearance‘s origin

69 DYF, see chapter X.2j of this thesis.

70 See chapter IX.1c of this thesis.

71 SYZJ / LQXZ, p. 175.

> is always in veinlets which can be found hidden between craggy rocks as tiny as a hair. The one who knows it, obtains it, uses a chisel and tries to smelt [it]. The ore's colour and appearance is varying, its purity is unequal, too. […] The depth of the veinlets cannot be estimated, some just appear on the surface of the earth [but] then disappear abruptly, some reach inside several *zhang* (1 *zhang* = 3.14 m) and then disappear, some remain very thin for a long time and then become very wide, some veinlets disappear in the middle [but if one continues] chiselling endlessly and repeatedly, one [can] see how flourishing they become again. These ones are called "passing through the wall". Some disappear all of a sudden while one is exploiting them and then reappear [within a range of] between eight *chi* and one *zhang*. These ones are called "toad jump". Normally, the mine workers exploit the ore like the bark-beetle the wood, sometimes to a depth of several *zhang*, sometimes to several tens of *zhang*, sometimes to several hundreds of *zhang*. According to the depth, [people] stop [exploiting them] when they break off.

Traditional Chinese miners apparently must have had this awareness and experience, although the earliest source treating this topic in detail is the much younger "Illustrated account of the mines and smelters of Yunnan" (*Diannan kuangchang tulüe* 滇南礦廠圖略) from the Qing Period, which distinguishes altogether twelve different shapes of ore deposits and classifies them according to their workability and potential.[72]

The frustration and hardship of the prospector's work, however, was reflected in the traditional saying "For one mountain which has [real] ore deposits there are one thousand mountains, which only have [superficial] veinlets" (*yi shan you kuang, qian shan you yin* 一山有礦，千山有引).[73]

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72 These twelve types are described and illustrated in detail in Golas (1999), p. 51, where he refers to DNKCTL, chapter 1.

73 Golas (1999), p. 209.

Nonetheless, Chinese miners and prospectors especially of the Song period were diligent and hard-working and if Hartwell argues that "every single occurrence of iron ore worked in modern China or reported by the 20th century geological surveys had been located by Chinese prospectors by the end of the 11th century"[74], a statement likely to be true for deposits of copper and many other metals just as well.

B) Exploitation

In order to obtain the ore material, which could later be processed further into metal, the located deposits needed to be exploited. This meant that a vein, if it did not directly meet the surface of the earth needed to first be reached by excavating a tunnel through earth or rock, then the ore needed to be obtained by striking, in some cases needed to be pre-selected underground and finally collected and hauled to the surface.

Excavating and striking

The tools, Chinese miners relied on remained largely unchanged over millennia since the beginning of larger mining activities until the advent of western mining technology in the 19th century[75], with the only difference in the material, which in the beginning mainly consisted in stone and wood, later in bronze and then for most of the time of course, iron.

74 Hartwell (1966), p. 33.

75 Golas (1999), p. 262f.

Fig 7: Chinese miner from the Qing period excavating with a spade in a coal mine. Source: Anonymous album from the Mid-19th century, Paris, Bibliothéque National (Estampes et photographies), Oe 116, pl.7.

Fig 8: Chinese miner from the Qing period striking rock with a gad and a mallet in a coal mine. Source: Anonymous album from the Mid-19th century, Paris, Bibliothéque National (Estampes et photographies), Oe 116, pl.12.

For gravelling and excavating in environments with earthen materials or soft and brittle stones, the tools applied for mining largely overlapped with the ones used in agriculture.[76] This is natural especially due to the fact that many of the miners were part-time farmers and used the same tools for both their occupations. These types of tools included hoes, spades, shovels and the like.

As far as striking into harder rock, as well as into most of the ore veins itself was concerned, the tools in use were of course different. Mallets with heads made of stone or wood were used together with iron headed hammers, different types of chisels and gads.[77]

If greater stretches of hard rock needed to be penetrated or if the rock or the ore were so hard, that treating them with such striking tools was impossible or would have been too slow or energy-consuming, a much used technology was firesetting. This method apparently in use in China, like in western Asia already since the late Neolithic and functioned in the following way: A large fire was lighted underground at the respective rock face in order to heat this as intensively as possible. After the fire was burnt down, the rock was quenched with cold water, in some cases also with vinegar in order to become brittle and could be worked easier afterwards.[78] The efficiency of this method could however vary greatly mainly due to the type of rock under consideration, but also to the air supply available to the fire and its position. The *Daye fu* includes a description of firesetting as well:

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[76] Golas (1999), p. 267.

[77] For a great variety of examples, see Golas (1999), p.265f.

[78] Golas (1999), p.300ff.

[…] 炮泐騈石之脅。[…] 磔蒼髯而可鑷。[…] 碓山藉礦而殷雷。[79]

[…] by using firesetting, the ribs of the solid rock are cracked. […] like a cut grey beard, but can be picked up with tweezers, […] like roaring thunder, the pounding of the rock and the collecting of ore.

and in another place:

宿炎煬而脆解，紛剞劂而巧斵。[80]

[Heated] by strong fire overnight, [the rock] becomes brittle and splits and by using numerous chisels and cutters it is skilfully chopped into pieces.

In its chapters about silver and copper mining, the Gazetteer of Longquan (*longquan xianzhi* 龍泉縣志) from the Song period, which stands in a close temporal and local relation to the *Daye fu*[81], firesetting is described in greater detail even providing figures on its efficiency:

舊取礦攜尖鐵及鐵錘，竭力擊之，凡數十下僅得一片。今不用錘尖，惟燒爆得礦。[…]採銅法，先用大片柴，不計段數，裝疊有礦之地，發火燒一夜，令礦脈柔脆。次日火氣稍歇，作匠方可入身，重錘尖采打。凡一人一日之力，可得礦二十斤，或二十四五斤。[82]

In former times [people] brought chisels and hammers made of iron to strike [the ore] with all their strength, [by striking] several ten times, they [could] only obtain one piece [of ore]. Today we do not use hammer and chisel any more but only burn and burst to get the ore. […] The method used to mine copper is to first use big pieces of fire wood, no matter of which length and how many and to install them piled up in a place with ore. After lighting it up and [letting it] burn for one night, the ore vein has become soft and brittle. On the next day, the fire air

79 DYF, see chapter X.2a of this thesis.

80 DYF, see chapter X.2k of this thesis.

81 See chapter X.1b of this thesis.

82 SYZJ / LQXZ, chap. 14, p. 175, 177.

> becomes less hot, then the workers can go in, beat with a heavy hammer and a chisel and collect [the ore]. Generally speaking, [with] one man's one-day workforce, one can obtain 20 *jin* of ore or [even] 24 or 25 *jin*.

Although gunpowder was invented in China during the Song period and was also extensively used there for fireworks and warfare, there is no evidence of any use of explosives and blasting in Chinese mines before the Ming period and even then it remained a rather isolated and rare case.[83]

Fig 9: Very steep gallery of a Song period silver-copper mine near Dexing, Jiangxi exposed by a hill slide (left) and adit leading into the mountain in the same place. Source: Photographs by the author.

Gallery construction

It is self-evident, that with these limited means of advancing a gallery in a hard rock environment, it was one of the foremost aims of miners, to keep

[83] Golas (1999), p. 306; Needham (1987), p. 542f.

their galleries as short as possible and to avoid excavating in dead rock as much as possible. The result of this condition is that Chinese underground mines at any time followed the ore veins closely, no matter how steep or crooked their course may have been.

Especially when galleries were excavated in an earthen environment or in somewhat softer rock, it was essential to support their walls and ceilings with strong wooden timbers in order to prevent collapsing. Much research has been carried out on the construction on of such timber structures in the earliest periods of Chinese mining for example for the copper mine of Tonglüshan 銅綠山 in Hubei but also for many other places.[84]

Timbering from the Song period, however has survived in many places as well. For instance at the modern open pit copper mine of Dabaoshan 大寶山 near Shaoguan in Guangdong Province, modern mining activities have disclosed timbering from the Song period in many places, which, however have not aroused much interests from historians or archaeologists and are thus successively destroyed.

In the Yongping 永平 open pit copper mine in Jiangxi, the same phenomenon can be observed. Local ore pickers working and living on the dump hills at the sides of the open pit mine collect this timber to obtain firewood for heating and cooking. (see Fig.1) From the fairly complete examples, which could be observed during the author's arrival at the Dabaoshan mine, it could be seen, that for at least some of the timbering the wooden beams were mortised in a quite simple way and after that bound together with ropes made of bamboo skin (see Fig. 11).

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[84] e.g. Vogel (1982) p. 147, but also many others, see Golas (1999), p.288ff.

Fig. 10: Remains of timber, presumably from a song period gallery in situ at the Dabaoshan open pit mine near Shaoguan, Guangdong province.
Source: Photograph by the author.

Fig. 11: Timber bound with bamboo skin rope at the Dabaoshan mine (left) and timbers collected as firewood at the Yongping mine.
Source: Photographs by the author.

Haulage

As a last step of underground mining, the usually roughly selected ore pieces needed to be transported from the depth of the galleries onto the surface. The work, energy and time necessary to execute this task of course depended heavily on the size of the mine as well as on other conditions such as the height, width and slope of the galleries as well as on the question if the main access to the galleries was achieved through a vertical shaft or a horizontal adit.

Under the most common conditions, which would have been that galleries were narrow and not high enough for a man to stand, haulers would carry two baskets tied around their shoulders and crouch or crawl with them out of the mine and back in again. Golas calculates that under these conditions four to five haulers needed to work in an average mine to clear out the ore and gauge produced by one miner striking, thus making haulers the by far biggest group of workers in the Chinese mines.[85] Close to nothing is known about the conditions of haulage in underground mines from the Song period, so it is necessary to rely on later observations from the Qing period or on the sparse archaeological evidence on the topic. What is sure is, that especially in mines with lots of vertical shafts, windlasses were used for the hoisting of ore baskets.[86] As for the use of haulage carts and sledges, which were witnessed by several European observers in the early 20th century,[87] it cannot be decided if they were only introduced recently following western examples or if they belonged to the

85 Golas (1999), p.311.

86 Already proven for the Tonglüshan mines, see Vogel (1982),p.143.

87 e.g. Andersson and Nyström, see Golas (1999), p. 314f.

traditional repertoire of Chinese mining practices. Under especially difficult conditions, it was apparently also possible for haulers to form human chains in order to transport material out of the mine (see. Fig. 12). Especially the difficult labour conditions of the haulers make any preference of miners for a work in over ground wet copper production facilities very understandable.

Fig. 12: Miners hoisting coal in a human chain fashion.
Source: Anonymous album from the Mid-19th century, Paris, Bibliothéque nationale de France (Estampes et photographies), Oe 116, pl.7.[88]

Weathering

If hauling was an extremely tedious work surely carrying the potential to ruin a worker's health within a certain period of time, other threats to the

[88] This illustration is included in: Golas (1999), p.317.

miner were of a much more immediate nature. Most importantly, this was the question of air supply in the mines. Although, because of the modest depth pre-modern Chinese mines usually reached, this problem may not have been as complex as in later European or American mines, but it surely existed. Altogether three possible types of air supply situations underground could have been dangerous for miners and thus have required measures to improve weathering:

1. Lack of oxygen: If the oxygen content of the air fell below 15 per cent, human activity would be strongly limited, below 10 per cent the situation could lead to the death of a miner within short. Especially because of the often crooked structures of veins and galleries, this was a major problem in copper mines.
2. Carbon dioxide: Inclusions in the rock, rotting timber and other phenomena often caused an increase of oxygen in the air. If the carbon dioxide content exceeded 18 per cent this could be lethal for miners as well.
3. Firedamp: This was predominantly a problem in coal mines, because of the frequent presence of coal dust, but also methane and other gases underground could explode upon ignition by the flame of a miner's lamp and in the worst case lead to a fire or the breakdown of the entire mine.

Besides, less frequently other types of poisonous gases may have appeared in newly opened deposits as well as in abandoned galleries as well.

Although these phenomena never ceased to pose a high risk for Chinese miners, they had means and ways to deal with it. Interestingly, one of the oldest descriptions of a preventative method against suffocation or explosions underground originates from the Censhui 岑水 mine near

Shaoguan in Guangdong province, which would later develop into the most important centre of wet copper production in China:

> 韶州岑水場，往歲銅發，掘地二十余丈即見銅，今銅益少，掘地益深，至七八十丈。役夫雲：「地中變怪至多，有冷煙氣，中人即死。」役夫掘地而入，必以長竹筒 端置火先試之，如火焰青，即是冷煙氣也，急避之勿前，乃免。有地火自地中出，一出數百丈，能燎人，役夫亟以面合地，令火自背而過乃免。有臭氣至腥惡，人間所無者也。忽有異香芬馥，亦人間所無者也。[89]

> At the Censhui mine in Shaozhou, in the past years, when copper was discovered, people dug the earth for [only] somewhat more than 20 *zhang* [ca. 63 m] and could already find it. Nowadays, the copper is becoming less and one digs deeper into the earth until 70-80 *zhang* [ca. 222 – 251 m]. The miners say: "There are countless evil apparitions underground. If one encounters 'cold smoke vapours (*lengyanqi* 冷煙氣)', one immediately dies." When they first enter excavation, the miners have to test the air with fire on the end of a long bamboo tube. If the flame turns blue-greenish, this is a sign of 'cold smoke vapours' and they should escape it hastily and not proceed any further. Then they can avoid [danger]. 'Earth fires (*dihuo* 地火)' originate underground can flare up to several hundred *zhang* and burn people. Miners [must] immediately lay down with their faces touching the ground in order to let the fire pass over their backs, then they can avoid [danger]. There is a stinking air with a disgusting smell like blood, which [otherwise] does not exist in the world. Suddenly there can be a magic fragrance like flowers, which [otherwise] does not exist in the world as well.

Generally already from the earliest periods of mining in China on, three main methods to improve air quality and to reduce dangers in the mines are identified by Golas[90]:

---

[89] TY, chap. 1.

[90] Golas (1999), p.331f.

1. Differential pressure method: Inside of the mine, shafts are established in a way that they connect the horizontal galleries inside the mine and thus create a natural airflow. This airflow was supported by smoothening the gallery walls through coating them with kaolin or bamboo strips. This Method, however usually only worked under rather cold outside weather conditions.
2. Furnace method: Weather shafts were established to connect the underground parts of the mine to the outside surface. at the bottom of these shafts, often fires were lighted in order to heat up the air in the shafts and let it rise.
3. Air pumps and fans: Although the idea of pumping and fanning foul air out of a mine may reach long back, most information on related technologies can only be found in the 'Illustrated account of the mines and smelters in Yunnan (*Diannan kuangchang tulüe* 滇南礦廠圖略)' from the 19th century. Though it may have worked efficiently, it was difficult and expensive to operate and thus probably not very much in use during the Song period yet.

Another way to reduce at least the risk of methane explosions was the use of special lamps without an open fire operated with oil rather than to directly enter a mine with burning torches. It is however not clear, since when such lamps were used, because the earliest evidence is an illustration from the 16th century (see Fig 14) and still during the late Qing period, open fires can be found in many mines.

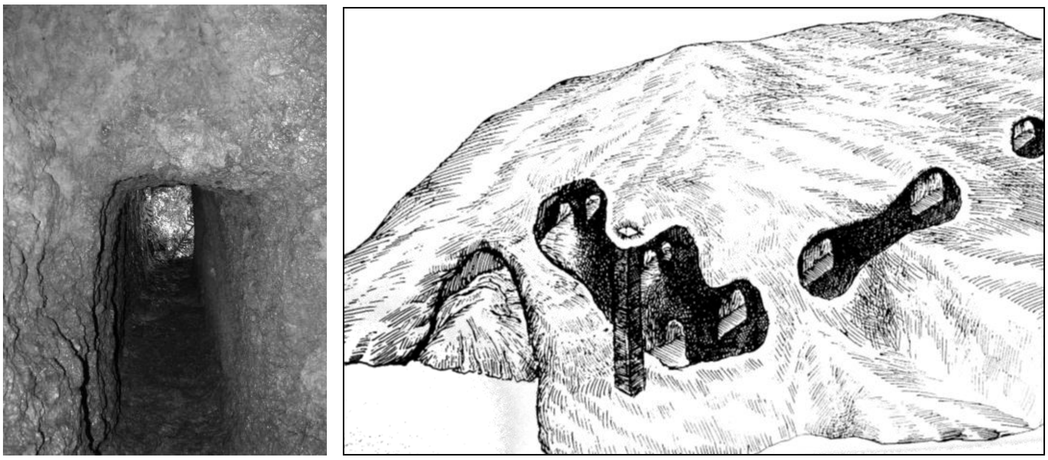

Fig. 13: A weather shaft in a copper-silver mine in Dexing (left) and a similar shaft in an illustration by the Dexing Museum. Source: Photographs by the author.

Fig. 14: A 16th century Chinese coal miner working by the light of two lamps with enclosed flames. Source: BCGM, *tujuan shang*, 11a.[91]

[91] see also Golas (1999), p.327.

Water management

One last problem of underground mining, which will be demonstrated in this place, is water management. As useful as water flowing through copper mines and copper deposits was if it could be canalised outside and used for wet copper production, as problematic, harmful and even very dangerous it could be for underground mining operations. Water could flow from outside into the mines as rain water or water from rivulets, or it could already be existent in the form of ground water and make the operation of mines below a certain depth impossible, if no means could be found to lift it. In the *Daye fu*, water in mines is mentioned in several instances. Such as in the chapter about gold mines, where it is mentioned, that underground gold mines may occasionally – probably seasonally – be filled with water:

> 尋苗覵汮之邃，破的礓壁之壅。[92]
>
> Veinlets are searched in holes which are sometimes filled with water, and their ends are smashed within the fillings of the earthen walls.

Another image provided in the chapter about silver mining gives the impression, that it must at least have been a common phenomenon that the ground of many galleries in underground mines was covered with water:

> 礲路深入，閣道横躡。篝燈避風而上照，梁杠揷水而下壓。[93]
>
> Entering through steep shafts, and stepping in through even adits. The fire in the bamboo lamp ducks away from the wind and shines upwards, the timber beams are stuck into the water and press downwards.

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[92] DYF, see chapter X.2g of this thesis.

[93] DYF, see chapter X.2h of this thesis.

But the *Daye fu* also mentions – though in a somewhat unclear mode of expression – one of the possible methods which could be used to transport water out of a mine:

> 戽楁深穽之腹，[…] 捷跳蛙其不繫。[94]
>
> By using buckets, the belly of the pit is drained […] Like a quickly jumping frog, but not fastened with ropes.

This passage describes the removal of water from the bottom of a mine with buckets. What remains largely unclear is in which way these buckets were used. Wang Lingling claims that this may have been the earliest indication for the use of a bucket-chain pumps in China, which – other than the square-pallet chain pumps much used for irrigation in China's agriculture – at this time are only known to have existed in Europe and the Middle East.[95]

This may be possible but is not necessarily true. Firstly, because the text reads clearly that it is "<u>not</u> fastened with ropes", which a bucket-chain pump would surely be. This argument alone however is not entirely conclusive, because a jumping frog in the nature would also not be fastened with ropes. It is thus still possible that the passage needs to be understood in a way, that it is the real frog is not fastened with ropes, but the buckets are. Secondly, even if the buckets, however, are fastened with ropes, this does not prove that this is the case in the shape of a bucket-chain pump. It seems to be even more likely that a simple bucket on a windlass with counterweight is described, a method for water lifting

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94 DYF, see chapter X.2h of this thesis.

95 Wang Lingling (2004), p.360.

already commonly in use in the famous Tonglüshan copper mine in Hubei during the Warring States period.[96]

Besides the use of buckets, water transport was also often carried out with a successive line of slightly inclined troughs, through which the water could either run until the next shaft exit or in the ideal case until it reached an adit inclined towards the outside.[97] More complex methods like the use of bamboo pipes pumping water out of galleries by means of underpressure were in use as well or are at least proven to have existed in 19th century Yunnan, but were surely very labour intensive and could thus not be applied everywhere at any time.[98]

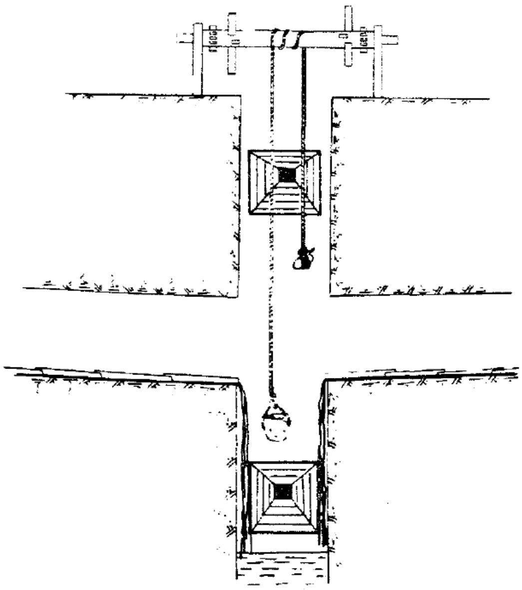

Fig. 15: Water raising at Tonglüshan using a windlass and bucket (modern illustration). Source: Golas (1999), p. 342.

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96 Vogel (1982).

97 Golas (1999), p.339.

98 Golas (1999), p.347f.

While smaller amounts of groundwater leaking into galleries could sometimes still be blocked away by wooden boards sealed with wool or other types of wall constructions,[99] in times when larger amounts of water entered a mine, miners often had no other choice than to abandon the it or to use it only part-time during the dry seasons. Often water also could break in and flood an entire mine by surprise causing the death of many miners.

C) Processing and Smelting

Processing

Ore processing describes all steps which are necessary between the mining of ore and the beginning of the actual smelting and refining process. What steps this can be is very much due to the composition of the ore and the metal one wishes to obtain from it later. The processing of those copper ores mined in China during the Song period seems to have been comparatively simple: The hard rock ore pieces often needed to first be roasted in special kilns with firewood as a fuel. Through this process, much of the contained sulphur could evaporate, the lead could liquefy and the rock would become brittle and easier to be broken into small pieces. From these small pieces, eventually the poorer one would be sorted out while the ones with a presumably higher copper content would be forwarded to the smelter. The *Daye fu* describes this long roasting process with the following words:

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[99] Golas (1999), p. 338.

> 徙堆阜於平陸，矗岑樓於爐步。熺炭周繞，藁薪環附。若望而燎，若城而炬。始束緼於畢方，旋皷鞴於熛怒。鞭火牛而突走，騎燭龍而騰鶩。戰列缺霹靂於燚庵，舞屏翳豐隆於煙霧，陽烏奪耀，熒惑遜度。石迸髓，汋流乳。[100]
>
> They shift [the ore] and pile up hills in the plain, and they erect high towers in the furnace place. They put glossy charcoals around and they attach dried firewood all over. Like a town, but burning; like a city, but set on fire. First they tie together [a piece of] linen with the Bifang [fire bird]; later they blow the bellows with fierce blaze. They whip the fire buffaloes which rush out abruptly, and they ride the torch dragons which soar up in a gallop. [Thus they cause] lightning and thunderbolt to fight in the blasting fire, and Pingyi and Fenglong to wield their weapons in the thick smoke. The sun bird is deprived of its shining, and Mars withdraws from his position. From ore, marrow is expelled, and from the core, milk flows out.

The appearance of a copper ore roasting kiln must have been in fact an impressive one. The related passage in the Gazetteer of Longquan reflects this as well, though naturally with much less poetic language:

> 用柴炭裝疊燒兩次，共六日六夜，烈火亙天，夜則山谷如晝。銅在礦中，既經烈火，皆成茱萸頭出於礦面。火愈熾，則鉛液成駝。候冷，以鐵錘擊碎，[…][101]
>
> Firewood and charcoal are piled up around [the ore] and it is roasted twice, all together for six days and six nights, The fierce fire reaches the sky so that the night in the whole valley becomes [as bright] as the day. As soon as the copper in the ore has passed the fierce fire, it all grows out of the ore's surface like dogwood sprouts. After the fire has continued burning vigorously, the lead becomes liquid and forms lumps. One then waits until [the ore] is cold, takes an iron hammer and crushes it into pieces […]

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100 DYF, see chapter X.2l of this thesis.

101 SYZJ / LQXZ, chap. 14, p. 177.

Apparently this way of roasting copper ore must have already consumed enormous amounts of fuel before any actual smelting process leading to the meltdown of all parts of the mineral in a furnace could even commence.

Smelting

The *Daye fu* includes a short description of the copper smelting process only, which does not provide much unexpected information. Apparently the ores which were subject to Hong Zikui's observation did also contain silver, which is a common phenomenon at some Chinese copper deposits.

> 鉐再鍊而麤者消，錏復烹而精者聚。排燒而汕溜傾，吹拂而黐窠露。[102]
>
> If the ore is smelted repeatedly then its crudeness is diminished, and if crude copper is heated again then its fineness accumulates. After blowing the bellows and burning, the liquid copper pours out, after blowing and fanning, silver is revealed.

One entry in the *Song huiyao jigao* from 1224 provides somewhat more precise information:

> 某日［…］名幾人入坑及采礦幾籮出坑，某日有礦幾籮下坊碓磨，某日有碓了礦末幾斤下水淘洗，某日有淨礦肉幾斤上爐烀煉，然後排燒窖次二十余日。每銅礦千斤用柴炭數百擔，經涉火數敷足，方始請官監視，上爐匣成銅。其體紅潤如煙脂，謂之山澤銅，鼓鑄無折而鑄出新錢燦爛如金。[103]
>
> Someday, […] several people enter the gallery, obtain ore several baskets out of the gallery; someday several baskets of ore is sent to the workshop for pounding and grinding; on another day, several *jin* of ore powder are washed in the water; yet another day several *jin* of pure "meat" of ore is put into the furnace for smelting. After that it is arranged into the burning chamber for more than twenty days again.

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102 DYF, see chapter X.2l of this thesis.

103 SHYJG / SH chapter 34, p.24.

> For every one thousand *jin* of copper ore, several hundred *dan* [1 *dan* = ~100 *jin* = ~66.1 kg] of firewood and charcoal are needed. Only when the number of times of burning is enough, officials are invited to supervise [the pouring of out of] the furnace [into the] mould for forming copper [ingots]. Its body has a ruddy colour like rouge and is called "mountain and marsh copper" (*shanze tong* 山澤銅). [If one uses it to] cast coins, there is no loss. The coins are brilliant like gold.

From this passage, it becomes obvious, how extremely fuel-consuming the smelting process for copper ore applied during the Song period was. For the smelting of 1000 *jin* of sorted, grinded and washed copper ore, 10 000 *jin* of firewood and charcoal were necessary, resulting in a relation between ore and charcoal of 1:10. This relation, however, does not consider the final outcome of pure copper yet; the relation between charcoal and pure copper may thus even have been a multiple of this figure. It is thus almost for sure remarkably higher than the relation estimated for the copper mines of Yunnan during the Qing period of 10:1 by Yang Yuda[104] or 14-15:1 by Vogel[105]

The most detailed account of copper smelting during the Song period, however, is still provided by the Gazetteer of Longquan. It continues:

> 入大旋風爐，連烹三日三夜，方見成銅，名曰生烹。有生烹虧銅者，必碓磨為末，淘去粗濁，留精英，團成大塊，再用前項烈火，名曰燒窖。次將碎連燒五火，計七日七夜，又依前動大旋風爐連烹一晝夜，是謂成釽。
>
> 釽者，粗濁既出，漸見銅體矣。次將釽碎，用柴炭連燒八日八夜，依前再入大旋風爐連烹兩日兩夜，方見生銅。
>
> 次將生銅擊碎，依前入旋風爐烀煉。如烀銀之法，以鉛為母，除滓浮於面外，淨銅入爐底如水，即於爐前逼近爐口鋪細砂，以木印雕字，作"處州

104 Yang Yuda (2004), p. 157-174.

105 Vogel (2008), p. 140.

某處銅”印於砂上，旋以砂壅印，剌銅汁入砂匣，即是銅磚，上各有印文。[106]

[One] inserts [the crushed ore] into a big whirlwind furnace and boils it there for three days and three nights, until the obtained copper becomes visible. This [process] is called "raw boiling" (*shengpeng* 生烹). If too few copper [appears] through the "raw boiling", one must pound [the ore] with a pestle and grind it into powder, wash impurities and dirt away and only keep the good and essence, [finally] form it into a big lump. Then again use fierce fire like before [to smelt it]. This is called "burning chamber" (*shaojiao* 燒窖). Then one burns the broken metal pieces five times in a row for seven days and seven nights. After that one puts them it into the before-used big whirlwind furnace and heats them there for one day and one night, this is called "forming *zhao*" (chengzhao 成釽).

Zhao is the copper's body which gradually appears after impurities and dirt have left. Now one breaks the *Zhao* into pieces, uses firewood and charcoal to heat it for eight days and eight nights, [then] again like before, one heats it in the big whirlwind furnace for another two days and two nights, then the "raw copper" (*shengtong* 生銅) appears.

The next step is to beat the raw copper into pieces, like before, and to place them into the whirlwind furnace for smelting. Like for the method of smelting silver, one uses the lead as a mother [substance], except that the dregs flow on the surface, the pure copper accumulates on the bottom of the furnace like water. In front of the furnace one prepares fine sand directly beside the mouth of the furnace. [One] carves the characters "copper [from] some place in Chuzhou" into a wooden stamp and presses it into the sand, then uses [some] sand to cover the print, again and pours the copper liquid into the sand box. These are now copper each, each of them bearing a printed inscription.

Following this description, smelting copper must have been not only a very fuel-consuming but also very time-consuming enterprise. Not even considering the previous efforts of processing and roasting, which may have been very different according to the ore's type and quality, the

106 SYZJ / LQXZ, chap. 14, p. 178.

smelting process of the copper ore until the desired purity was reached must have taken at least three weeks!

When this was the case, the copper could be cast into ingots, which was interestingly carried out with a very similar method like the casting of coins in the mint.[107] Sand moulds were prepared with an imprint of a carved wooden stamp on it, ensuring that the inscriptions on the face of every ingot at least from the same smelter must have looked alike.

> 每歲解發赴梓亭寨前，再以銅入爐烀煉成水，不留纖毫深雜，以泥裹鐵杓，酌銅入銅鑄模匣中，每片各有鋒[蜂]窠，如京銷面，是謂十分淨銅。發納饒州永平監應副鑄。大率烀銅所費不貲，坑戶樂於采銀而憚於采銅。銅礦色樣甚多，烀煉火次亦各有異。有以礦石徑燒成者，有以礦石碓磨為末如銀礦燒窖者。得銅之艱，視銀蓋數倍雲。[108]
>
> Every year before [the copper] is to be delivered to Zitingzhai[109], [one needs to] put it into furnace to melt in into liquid, not leaving any little piece of impurity. [One] uses an iron ladle which is covered by clay to ladle copper [melt] out and pour it into the mould box which is cast of copper. Every piece carries a honeycomb pattern like on the surface of a "capital-cast" (*jingxiao* 京銷) [silver] ingot, this shows that the copper is one hundred per cent pure. It has to be transported to the Yongping [industrial] prefecture in Raozhou for minting. Generally, the cost of smelting copper is enormous. Mining households are happy to mine silver but afraid to mine copper. The types of copper [ores] are various, and [requirements for their] roasting and smelting are also different. Some ores can be directly smelted to obtain copper, some ores need to be pounded and grinded into powder, then smelted like silver ore in a "burning chamber". The difficulty to obtaining copper, compared with silver, is several times [higher].

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107 See chapter III.2C of this thesis.

108 SYZJ / LQXZ, chap. 14, p. 178.

109 Place name in Longquan with a police station.

4) Monies in Song China

A) The Variety of Monies in Song China

Of all the Chinese dynasties, the Song may well have had the most complex monetary system. Peng Xinwei 彭信威 lists five reasons, which contributed to this complexity and made the monetary system of the Song period different compared to other Chinese dynasties:[110]

1. Different materials: Cash coins formed the basis of the system and were cast from bronze or iron. Additionally, paper notes as well as uncoined silver and gold were circulating and took over partial or complete monetary functions as well.
2. Localised circulation: Due to its origins in a time of territorial fragmentation, the importance of borders to its often enemy neighbours as well as due to the different availability of metals, the monetary system of the Song period was not unified but showed great local variations. This especially concerned the use of bronze and iron coins.
3. Different sizes: Song coins showed a great variety of face values, which was also reflected in the size and weight of coins, but did not necessarily reflect the intrinsic value.
4. Different names: No dynasty cast coins with as many different names as the Song. Close to every reign period, of which most Song emperors had several, introduced new coins with often still

[110] For these basic information on the monetary system of the Song period see Peng Xinwei (1966), p. 332ff.

different names such as "Original Treasure" (*yuanbao* 元寶), "Circulating treasure" (*tongbao* 通寶), in one case up to 24.[111]

5. Different styles: The Song mints produced coins with a great variety of different writing styles and calligraphies on them. Of nearly every type of coin editions with at least two different styles, often with many more existed, of which some could have been designed by famous scholars and reputed calligraphers.

Fig. 16: Iron coin with a calligraphy in the so-called "slender gold script" (*shou jin ti* 瘦金體) by emperor Huizong (r. 1101-1125).
Source: http://primaltrek.com/chinesecoins.html#northern_song_dynasty.

[111] The iron coins of the Jiading 嘉定 reign period (1208-1224) had up to 24 different treasure names, see Peng Xinwei (1966), p.332.

B) Bronze Cash

The latest since the Han period (206 BC – 220 AD), round copper coins with a rectangular hole in the middle had developed into the most important and with very few exceptions only actual money in China proper. Of course barter trade and the quasi-monetary use of commodities like cloth, rice or salt continued in parts until the Qing period. Two important events within the development of bronze coinage before the song period need to be noticed: Firstly, the introduction of the Wuzhu 五銖 coins by Han Wudi, which defined the minting monopoly of the state in and fixed the weight for one coin at five *zhu* 銖 (ca. 3.25g at that time) in the year 118 BC.[112] Secondly, the introduction of the Kaiyuan tongbao 開元通寶 coins in the year 621 during the early Tang period, when emperor Gaozu removed the close link between a coin and its weight from the name and instead defined it as the emperor's "(circulating) treasure" (*(tong)bao* (通)寶), a value for which not only the material of the coin accounted but the state represented by the emperor himself.[113] 340 years later, when the Song dynasty was founded, this idea was basically still leading the Chinese understanding of cash, but due to several economic crises requiring special issues as well as due to the political fragmentation, which China had undergone during the period of the Five Dynasties and Ten Kingdoms (907-960), coins were now generally named after their reign period of issues and the number of types, sizes and values had increased enormously.[114]

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112 Peng Xinwei (1966), p. 106.

113 Peng Xinwei (1966), p. 250.

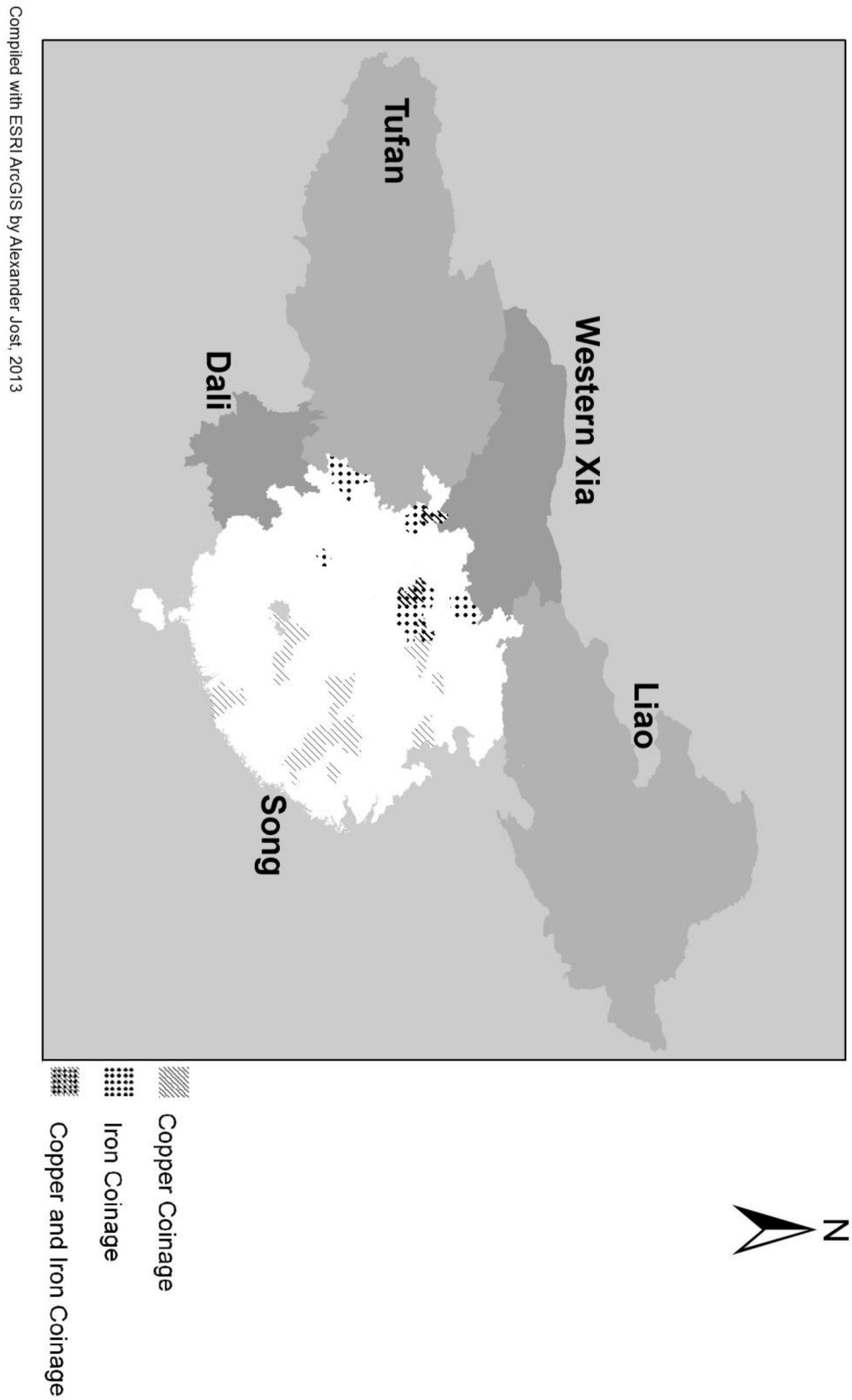
114 Peng Xinwei (1966), p. 332.

Copper cash was the most common currency used for close to any transaction in everyday life. Usually 1000 coins (*wen* 文) were threaded on one string (*guan* 貫) for transport and to facilitate counting in larger transactions.

C) Iron Cash

Due to its low market value, its high specific weight and its tendency to corrode easily, iron has never been a preferred mint metal. Consequently its short history in the context of the Chinese monetary system began only much later than the one of copper cash with some special issues during the time of the Five Dynasties and Ten Kingdoms. During the Song period, however, iron coins became an integrated part of the monetary system in several regions of the empire.

The reasons for this development were mainly two: firstly, at times copper was not enough to cover the coinage demand in the entire country. In this case, copper cash was issued in regions situated closer to copper mines, while iron cash was issued in regions closer to iron mines. Secondly, during the Song period, especially at times, when China's copper production flourished, copper coins as raw material were very popular as an item of export. To avoid losing copper especially to its mostly enemy neighbours to the north and west, the Song state thus often issued iron coins in these border regions instead. Because the regions with rich copper mines were anyway rather situated in the south-east and thus far at least from the land borders, a regional distribution pattern as shown in Map 1 evolved. The exact territories for the use of iron coins, however, are not known, only the territories of the prefectures producing them.



Map 1: Coinage Directorates in Northern Song China around 1080.
Source: Wang Shengduo (2003).

D) Paper Money

Paper money was a currency different from all other means of payment in one decisive aspect, which is, that the objects handed over during a process of payment had no or only marginal intrinsic value. Instead, the idea behind it was, that the holder of a paper note would have the right to exchange it back to another currency whenever he wanted and that this option was guaranteed either by a bank or similar private institution or by the state itself.

The worldwide first appearance of a currency functioning according to this pattern took place in China during the Western Han period (207 BC – 9 AD) and interestingly did not use paper but square-foot-sized pieces of white deer skin. The first notes, which were actually made of paper was the so-called "Flying Cash" (*feiqian* 飛錢) of the Tang Dynasty. [115] Both these phenomena, however were only used in very particular situations and did not really achieve the status of a circulating currency. For the deer skin this was apparently the case, because its production cost was relatively high and the absence of printing technology prevented even the most rudimentary protection against forgery. The "Flying Cash" in turn, though in its appearance surely more similar to the later paper money, must have served rather as a credit medium than an actual circulating paper money currency.[116]

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115 Peng Xinwei (1966), p. 367.

116 Tsien Tsuen-hsuin (1985), p. 96.

Fig. 17: Print from the earliest surviving block for printing paper money (ca. 1024-1108). Source: Tsien (1985), p. 97.

The origins of regularly circulating paper money are to be found in the Song period as well, a fact for which Peng Xinwei sees four reasons:

1. The increasingly commercialised economy of the Song period required money, which was available in much larger amounts and still very convenient to handle.
2. The monetary system of the Song period was much regionalized,[117] not every form of cash was accepted everywhere and at times bringing cash from one province to another was forbidden.

[117] see e.g. map 1.

3. Especially the iron coins circulating in some regions were unsuitable to be transported in larger amounts on longer journeys and were thus often replaced by paper money.
4. The Song government had to cover enormous expenses especially for its military, which had do be kept on alert nearly without interruption because of the enduring threats from the northern borders of the country.[118]

It is apparent, that by the Southern Song period, paper money had reached a very remarkable role within the monetary system of the country. It is reported that for instance in the year 1175 the paper for the printing of paper money alone was produced in four government-owned factories, one of which employed more than 1000 workers.[119]

During the Yuan period (1279-1368) when the payment in metal currencies was almost entirely abolished by the Mongol rulers, the history of paper money in China reached its heyday but at the same time began to decline, because of excessive and incompetent use by the government.

E) Silver and Gold

Like elsewhere in the world, gold and silver were considered to be highly appreciated valuable metals in China during any time period as well. To the opposite of other world regions, however, they hardly ever came into circulation in a coined form. Gold coins were only used as an important means of payment and exchange during the Warring States period (475 BC – 221 BC) in the Kingdom of Chu. Less important were small issues of

118 Peng Xingwei (1966), p. 367.

119 Tsien Tsuen-hsuin (1985), p.48.

gold cast or forged into the shapes of horse hooves (*niaoti* 褭蹏 or qilin feet (*linjiao* 麟腳), used mainly during the Han period by the court for the rewarding of officials. During the Song period, gold and silver were cast into the shapes of cash coins as well, but also employed for very limited uses, like the rewarding of officials or ritual uses, only.[120]

As far as silver was concerned, its use as an uncoined medium of transaction was during the Song period already fairly developed, although it had not reached such a status yet that one could talk about a bimetallic system like during the Ming and Qing periods yet.[121]

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120 Peng Xinwei (1966), p. 357ff.

121 For detailed analyses concerning the development of uncoined silver as a currency in late imperial China see e.g. von Glahn (1996).

III) Mining and Minting Institutions

1) Mining and Minting Administration

A) General Institutions

During the Song period, the administrative institutions in charge of mint metal production and coinage were closely intertwined, in many cases even identical.[122] This reflected the strict monopoly, the state held on mint metals and their production. For the structure of these institutions two phases can be distinguished:

Before the so-called "Yuanfeng Reform" in 1080, on the central government level, the State Finance Commission (*sansi* 三司) was in charge of finance, which was an aggregation of the Salt and Iron Monopoly Bureau (*yantiesi* 鹽鐵司), the Tax Bureau (*duzhisi* 度支司) and the Census Bureau (*hubusi* 戶部司). Under the Salt and Iron Monopoly Bureau there were seven sections (*an* 案), one of which was the Iron Section (*tie'an* 鐵案), who dealt with gold, silver, copper, iron mining – and with minting[123].

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[122] For a very detailed discussion of the underlying administrative System, see Wang Shengduo (2003). Information not otherwise indicated in this chapter refers to this work as well.

[123] SS, chap. 162, *zhiguan er* 職官二.

After the "Yuanfeng Reform", this State Finance Commission was abolished. Minting affairs were shifted to the Ministry of Works. On the lower administrative levels, however, this reform did basically not implement any major changes.

As to the regional and local administration, Song China's system generally speaking encompassed three levels: circuits or "provinces" (*lu* 路), prefectures (*zhou* 州) and districts (*xian* 縣). Among the circuit supervisors (*jiansi* 監司), the Fiscal Commissioner (*zhuanyunshi* 轉運使) held the general responsibility for tax assessment and collection and all other fiscal matters. There were also some circuit supervisors whose responsibilities transcended the borders of the singular circuits. One of them was the Commissioners for Foundry and Coinage (*tidian kengye zhuqian shi* 提點坑冶鑄錢使). Another one was the Supply Commissioner (*fayunshi* 發運使) who supervised the forwarding of taxes and revenues from the state monopolies to the capital; he could also be in charge of mining and minting affairs[124].

The most influential institution in this field, however, was the Commission for Foundry and Coinage (*tidian kengye zhuqian si* 提點坑冶鑄錢司). Its name changed from time to time, sometimes it was prefixed with a "chief" (*dadu* 都大)[125], sometimes it was clearly identified with its territory of activity in the south-east of the country like "Jiang, Zhe, Jinghu, Fujian, Guangnan and other circuits" (江浙荊湖福建廣南等路), sometimes its territory was just summarised by "the nine circuits of the Southeast" (*dongnan jiulu* 東南九路). Its main task was to supervise the

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124 Wang Shengduo (2003), p. 36ff.

125 SS, chap. 167, *zhiguan qi* 職官七.

minting of copper cash in special time periods also of iron cash minting, as well as the mining for different related minerals, which could mainly be found in the southeast of Song China.

It was first established in 1035 with its headquarters in Raozhou[126] and experienced several phases of unity and division according to the development of mining scale and minting quota:

- In 1079, it was divided into two institutions: one was in charge of Huainan, Liangzhe, Fujiang and Jiangnan East, with the headquarters situated in Raozhou; the other one for Jinghu, Guangnan, Jiangnan West, with its headquarters in Qianzhou. In 1086 they were merged again.
- Around 1112, it was again divided into two parts: one for Jinghu, Huainan and Jiangnan East which was directed from Qianzhou and one for Jiangxi, Liangzhe, Fujian and Guangdong West which was directed from Tanzhou but later moved to Raozhou. In 1135, this office in Raozhou was merged again with the one in Qianzhou.
- After another division in 1171, Jiangnan, Huainan, Tongchuan, Liangzhe and Lilu belonged to Raozhou; Jiangxi, Huguang and Fujian belonged to Ganzhou. In 1175, however, the Ganzhou office was merged was united with the Raozhou one in Raozhou again and a "chief" was added as a prefix. This name was kept and the office was not separated any more. It was this office, which finds mention in several Places of the *Daye fu* and which may have been the source for many of Hong Zikui's information.

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126 XZZTJCB, vol. 117, eighth month in the second year of the Jingyou reign-period, *jimao*.

The responsibilities of the Commissioner for Foundry and Coinage consisted in the production of copper, lead, tin and iron as well as in the casting of coins. The mining of silver and gold, however, belonged to the responsibilities of the Fiscal Commissioner. The Commissioner for Foundry and Coinage chiefly carried the task of making suggestions and plans which were related to mining and minting affairs. Although he did not directly control the officials of those industrial prefectures, prefectures, districts, mines and mints in its territory, but he had the power to supervise, recommend and where necessary impeach the officials in the respective administrative units. Besides, he also had his own subordinate officials and clerks, which will be introduced in detailed later.

The territory was vast (several circuits in the southeast, varying with names and numbers from time to time), covering more than one hundred prefectures and four to five hundred districts. The Commissioner's wide range of responsibilities and the large territory lead to two problems:

- Due to the transport and communication conditions at that time, supervision and inspection over such a large area was difficult and travel was slow and tedious. One official, Zhang Ciyuan 張次元, even died on his duty.[127]
- Due to the large number of involved regional institutions, the relation with their officials was hard to handle. It was thus always a subject of discussion, how much power the Commissioner should have. If he was too powerful, the local governments' power would be invaded and they would resent; if he was made too powerless, the local governments could not be forced to finish their tasks.

127 Wang Shengduo (2003), p. 51.

The numbers and types of subordinate officials and clerks of the Commissioner varied from time to time. Table 1 displays the situation in 1159.

Tab. 1: Officials and clerks directly subordinate to the Commissioner for Foundry and Coinage in 1159.[128]

Type	Name	Number
Subordinate officials	*Zhuguan wenzi* 主管文字 (Superintendent of textual work)	1
	Ganban gongshi 幹辦公事 (Administrator)[129]	1
	Jianta guan 檢踏官 (On-spot inspector)	2
	Chengtong guan 稱銅官 (Weighing copper official)	1
	Cuigang guan 催綱官 (Promoting transport official)	1
Clerks of Commissioner	*Shoufen* 手分	10
	Tiesi 貼司[130]	2
	Jundian 軍典	1
Clerks of subordinate officials	*Shoufen*, T*iesi* and *Jundian*	10

128 SHYJG / ZG, p. 43ff.

129 Hucker (1985), item 3136.

130 Hucker (1985), item 6513.

One special institution which was founded for the purpose of promoting wet copper production in particular deserves special attention although it was rather short-lived: The so-called Supervisor for the management of copper affairs in Jiang, Huai, Jing, Zhe, Fujian and Guangnan (*Tiju cuozhi Jiang Huai Jing Zhe Fujian Guangnan Tongshisuo* 提舉措置江淮荊浙福建廣南銅事所)[131] which was established during the Shaosheng reign-period by the Zhezong emperor (1094-1098). You Jing 游經, who was the first person to promote wet copper production, was appointed to serve on this position. However, it seemed to only exist during You Jing was in charge.

B) Local Institutions

While the before mentioned institutions and officials all belonged either to the central administration or were equal with the circuit level, especially in regions with state-relevant industries, many more institutions could be established, these were:

- **Industrial Prefecture (*jian* 監):**
  Prefixed with a place name, identifying a Prefecture-level agency in an area where a preeminent economic enterprise was a mine, a saltern, or something of that sort that required the special attention of local officials. One *jian* could control many pits, mines, smelters and enterprises.
- **Smelter (*ye* 冶) [132] or enterprise (*wu* 務):**
  Production unit for prospection, exploitation, smelting and other

[131] SHYJG / ZG chapter 43, p. 121; SHYJG / SH chapter 34, p. 25.

[132] According to Hucker, *ye* stands for mint. Maybe it is a shorted version for *yetai* 冶臺. *Jian* could also mean mint, in this case they were called *qianjian* 錢監., see Hucker (1985), item 7906.

separate processes. Smelters and enterprises could be independent units, or could be placed under the supervision of a *jian*. *Ye* and *wu* often appeared together in names. The leaders could be either appointed official or private merchants who bought their producing rights from the government.

- **Mine (*chang* 場):**

  Most common producing unit especially in the context of copper production. Sizes and worker amounts varied greatly. Normally middle or small sized, but sometime could also be extremely large, e.g., the mines at Yanshan and Censhui may have had more then 100 000 workers at times.

- **Pit (*keng* 坑):**

  Most basic unit for mining activities. A pit could be independent or under the control of a *jian*, *ye*, *wu* or *chang*. This name was mainly used in the south such as in the circuits of Fujian and Jinghu South but seldom seen in the north.

According to Wang Lingling, the producing units *jian*, *ye*, and *wu* were normally directly operated by the government, while *chang* and *keng* were normally privately managed[133]. However, when examining the wet copper producing units in particular, this cannot be fully confirmed. They were often entitled as *chang*, for example, Censhui chang, Yanshan chang, although they were clearly operated by the government. The reason why the Yanshan and Censhui mines in the aspects of size as well as official-private operation both appeared to be unordinary is probably also exactly due to the fact they were wet copper mines.

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133 Wang Lingling (2005), p. 29.

Generally speaking, industrial prefectures were attached to prefectures, except of several very large ones, which were themselves equal to prefectures, for example, the Guiyang industrial prefecture. Among the mines and enterprises, the bigger ones were attached to prefectures, smaller ones were attached to districts, but all of them had to maintain a close relationship with the above mentioned Commissioner. For each *jian*, *chang* and *wu*, one supervisory official (*jianguan* 監官) was appointed, which was normally a rather low-ranked civil or military official. For the big industrial prefectures, one prefect (*zhijian* 知監) was in charge.

2) Mints

A) Mint administration

The basic units of casting coins were called "Directorates of Coinage" (*qianjian* 錢監). They were usually placed under the control of the prefectures. There were two types of mints: mints for copper cash and mints for iron cash. However, also this division was not an absolute one; some Directorates of Coinages for copper cash could sometimes also cast iron cash, but the Directorates of Coinage for iron cash normally did not cast copper cash.

The scale of directorates of coinage varied. The bigger ones of the Northern Song could have more than 1000 soldiers and workers at one time. Those of the Southern Song period were smaller. The biggest one from this time should be again the Yongping mint in Raozhou, which employed 314 soldiers and craftsmen[134].

The responsible officials of the directorates of coinage were so-called "Supervisory Officials" (*jianguan* 監官). Bigger directorates had two to three supervisory officials, smaller ones had only one each.

The workforce who served in the mints can be divided into four types: skilled craftsmen, unskilled workers, soldiers, and prisoners. These four groups could overlap (e.g. prisoners could serve their sentence in military service) and there were chances for ascent (e.g. a prisoner could achieve the status of a normal worker after long satisfactory service or an experienced unskilled worker could reach the status of a skilled craftsman). Casting coins was a hard and heavy work, during the Northern Song it was better paid and the workforce consisted predominantly in craftsmen and workers, while during the Southern Song, payment was worse and there were more soldiers and prisoners.[135]

There were other institutions in charge of mining and minting in Song China. Or instance during the Northern Song period, the above mentioned Commissioner for Foundry and Coinage was only in charge of the south-eastern regions of China, while in the southern Song period, even in the south-eastern regions, where existent, the casting of iron cash belonged to other institutions[136]. Since this particular aspect is less relevant for the topic of this thesis, further discussion is not necessary here.

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[134] SHYJG / ZG chapter 43, p.162.

[135] Wang Shengduo (2003), p. 124.

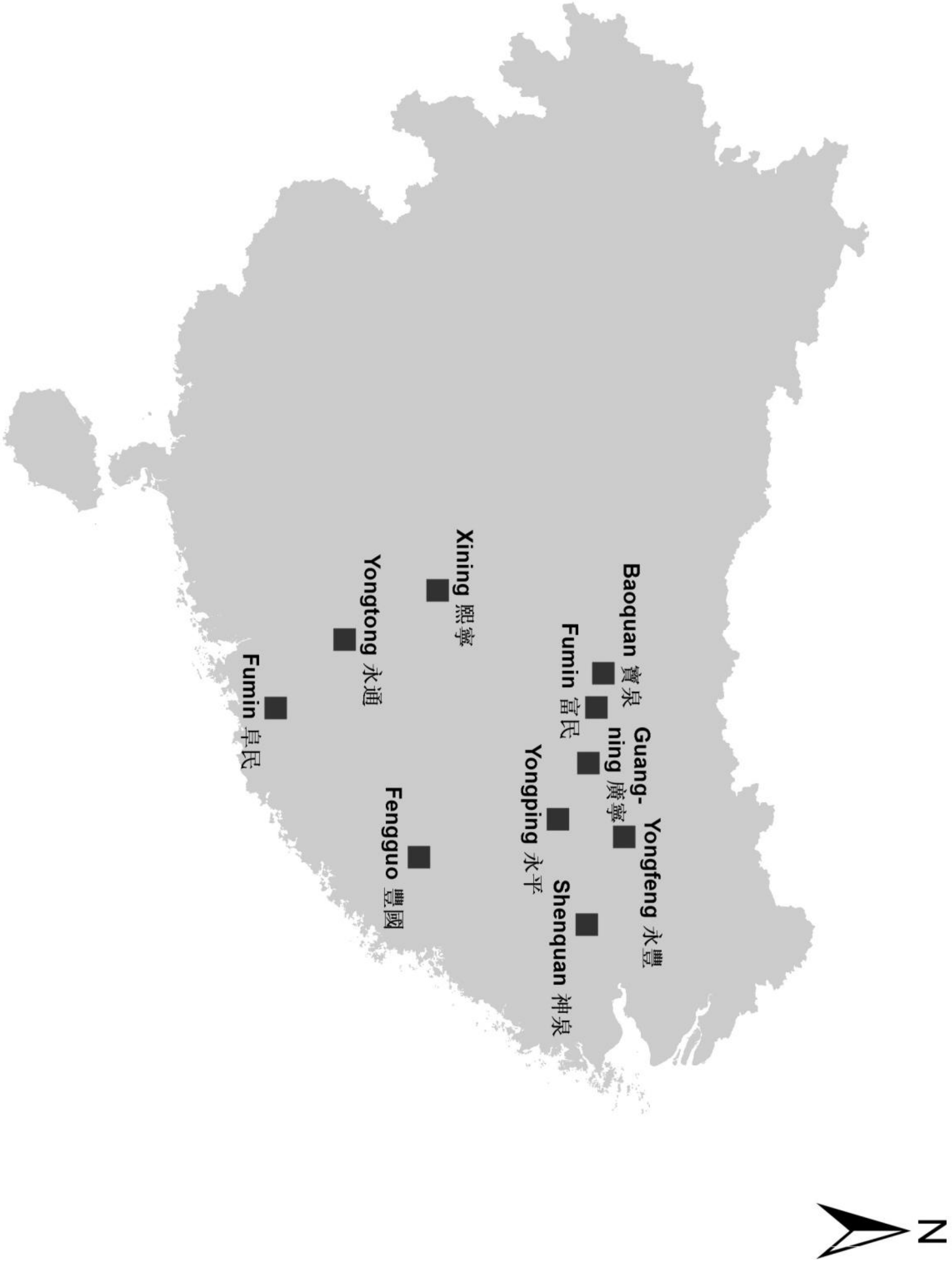
[136] Wang Shengduo (2003), p. 55 f.

B) Mint Locations

Generally speaking, the locations of mints were not necessarily close to mining regions, but all had in common that their locations were convenient for transportation, there were no more than 20 mints for copper cash operating at the same time, but with mints frequently closing down and new mints opening again, throughout the Song period there were 38. There were more directorates to the south of Yangtze than to the north, and they also had a higher production capacity.

The *Daye fu* mentions ten of the altogether existing 38 copper cash mints which existed over the time of the Song period, including the most important institutions of its time. These are displayed in Map 2.

In the following, a complete list of all copper cash mints ever in operation during the Song period are displayed with their opening and closing times in Table 2.



Map 2: Important Minting Prefectures in Song China around 1200; only territories ruled by the Southern Song Dynasty displayed. Source: DYF et al. Compiled with ESRI ArcGIS by Alexander Jost, 2013

Table 2: Mints for Copper Coins in Song China[137]

Nr.	Name of *jian*	Time	Location	Remarks
1	Yongping 永平	758~760 until the end of Southern Song	Raozhou 饒州	Longest, most important, the only one at the end period of Southern Song.
2	Yongfeng 永豐	995~997 - 1132	Chizhou 池州	Incorporated into Yongping
3	Guangning 廣寧	999 - 1132	Jiangzhou 江州	Incorporated into Ganzhou / Qianzhou Mint
4	Fengguo 豐國	Existed since five dynasties, rebuilt 999, closed 1132, reopened again and closed 1175.	Jianzhou 建州	
5	Yongtong 永通	1048-1185	Shaozhou 韶州	Biggest from the middle until the end of Northern Song
6	Fumin 阜民	1067-?-closed?-1104 reopened-?	Huizhou 惠州 (Guishan District 歸善縣)	
7	Capital Mint 京師鑄錢監	?	Kaifeng	Unclear. Only short time at the beginning of the Northern Song.

137 Compiled with data from Wang Shengduo (2003), p. 81ff.

8	Baoxing 寶興	Existed since Tang, reopened ~ 997, closed 1016.	Hangzhou 杭州	
9	Shengzhou Mint 升州錢監	~ 939 until before 1022	Shengzhou 升州	Unclear. Only short time at the beginning of the Northern Song..
10	Nan'anjun Mint 南安軍錢監	~1020	Nan'anjun 南安軍	Unclear. Only short time at the beginning of the Northern Song.
11	Zhuyang 朱陽	1041-?	Guozhou 虢州 (Zhuyang District 朱陽縣)	changed to casting iron coins during the Yuanfeng reign-period (1078-1085)
12	Fumin 阜民	1041-?	Shangzhou 商州 (Luonan District 洛南縣)	changed to casting iron coins in 1075.
13	Boji 博濟	1044 - ~ 1067	Yizhou儀州 / Weizhou 渭州 (Huating District 華亭縣)	
14	Jingzhao Mint 京兆府錢監	1071 - ~1092	Jingzhao fu 京兆府 (Yongxing jun 永興軍)	The same jurisdiction had an iron cash mint, too.
15	Shanzhou Mint 陝州錢監	1071 - ~1092	Shanzhou 陝州 (Shanfu 陝府)	The same jurisdiction had an iron cash mint, too.

16	Huazhou Mint 華州錢監	1071 - ~ 1078	Huazhou 華州	The same jurisdiction had an iron cash mint, too.
17	Fengxian Mint 鳳翔錢監	1074-1079	Fengxiang Prefecture 鳳翔府 (MeiDistrict 郿縣)	
18	Tongyuanjun Mint 通遠軍錢監	1079 - after 1113	Tongyuan jun 通遠軍 (Weiyuan town 威遠鎮)	Changed from an iron mint.
19	Guangfu 廣阜	1107 - ?	Lanzhou 蘭州	
20	Liyang 黎陽	1074- closed - reopened in 1104, closing time unclear	Weizhou 衛州	
21	Zhenzhou Mint 真州鑄錢監	1107 - ?	Zhenzhou 真州	
22	Cizhou Mint 磁州錢監及鑄錢院	1113 - ?	Cizhou 磁州	
23	Fucai 阜財	1074 - ?	Henan Prefecture 河南府 (Heqing District 河清縣)	
24	Jiangzhou Mint 絳州錢監	Before 1075 - , after 1078	Jiangzhou 絳州 (Yuanqu District 垣曲縣)	

25	Baofeng 寶豐	1083 – 1085, reopened in 1104 - closing time unclear	Xuzhou 徐州	The same jurisdiction had an iron mint too.
26	Ruzhou Mint 汝州錢監	1105-?	Ruzhou 汝州 (Lushan District 魯山縣)	Possibly an iron cash mint.
27	Huaizhou and Weizhou Mint 懷州、衛州鑄錢院	1108 - ?	Huaizhou 懷州 and Weizhou 衛州	
28	Tong'an 同安	1075 - after 1110	Shuzhou 舒州 (Anqing Prefecture 安慶府)	
29	Shenquan 神泉	1074- 1190 reopened in 1197, closing time unclear.	Muzhou 睦州	
30	Fumin 富民	Probably before 1048 - ?	Xingguo jun 興國軍 (Daye District 大冶縣)	
31	Baoquan 寶泉	1074- 1102 reopened soon, closing time unclear	Ezhou 鄂州	
32	Xining 熙寧	~1074 - ?	Hengzhou 衡州 (Hengyang District 衡陽縣)	

33	Yuanfeng 元豐	~1083 - ?	Wuzhou 梧州	
34	Qianzhou / Ganzhou Mint 虔州/贛州鑄錢院	1110-1195	Qianzhou 虔州 / Ganzhou 贛州	
35	Yingzhou and Lianzhou Mint 英州連州鑄錢院	1109 -?	Yingzhou 英州 and Lianzhou 連州	
36	Baoji 寶積	~ 1111- ~ 1125	Yongzhou 邕州	
37	Xinzhou Mint 信州鑄錢院	Around 1121	Xinzhou 信州 (Yanshan District 鉛山縣)	

C) Minting Technology

As usual for Chinese coins since their earliest appearance one and a half millennia earlier, during the Song period, coins were directly cast prepared moulds, a process that unlike for western coins did not involve striking with dies. The first step of minting, however, was the same: The raw metal, which arrived at the mint usually in the form of ingots, but could of course also consist in other metal objects or even in old coins, which had to be recast for various possible reasons. This metal needed to be estimated according to its quality and purity, before it could be molten down and mixed into the respective necessary alloy.[138] The *Daye fu*, which

[138] This alloy was throughout the Song period very frequently subject to minor changes, which will not be discussed here in detail. Excellent Studies on this subject are

is the only available source on the minting technology of the Song period describing the process with at least some level of detail, begins like this as well:

> 鑄錢使攷其會，辨銅令第其品。[139]
>
> […] the coinage commissioner inspects the alloy's colour, the director of grading and sorting raw copper evaluates its quality […]

After the evaluation and sorting of the raw copper, tin and lead pieces, they needed to be molten down, a process, which surely required a deliberately lighted fire, though not necessarily as impressive as the *Daye fu* describes it with numerous borrowings from mythology:

> 煤突整潔，炭戶充牣。鼓兩儀之籥而大播，役六丁之工而迭運。祝融作，女媧進。一煽濤生海門之微波，再煽日吐扶桑之暈疊，三煽烘朝霞而爛照，四煽洶屯雷而欲震。張格澤之輝飈，迸攙搶之芒潤。夸父即之，汗翻漿而暍；河伯望之，瞳眩花而瞬。澄澈不殽，通明無燼。黑濁之氣竭而黃氣次，黃白之氣竭而青氣應。[140]
>
> The sooth chimneys are neat and clean, and the charcoal-producing households plentiful and abundant. There is huge agitation by blowing the 'bellows of the Two Powers', and "operation in change and circulation" is carried out employing the efforts of the [gods of the] six combinations. Zhu Rong acts and Nüwa promotes. The first blow-a big wave is created by the light ripples at the entrance of the sea; again a blow-the sun is disclosed by the multi-layered aurora at the Fusang tree. The third blow heats up the rosy clouds of dawn and gives them the full brightness, and the fourth blow incites the thunder until it is about to tremble. Displayed are the brilliant flumes of the Heze [star], and spilled are the glossy rays of the Chanqiang [comet]. If Kuafu approached [the fire], [his] sweat would turn viscous and he would suffer a heat stroke, if Hebo looked into it, his pupils would become dazzled and he would

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provided e.g. by Wayman & Wang (2003) or Zhou Weirong & Fang Xiangxi (1993) et al.

139 DYF, see chapter X.2p of this thesis.

140 DYF, see chapter X.2p of this thesis.

> blink. Transparent throughout and spotless, thoroughly bright and without ashes! When the black and turbid smoke is exhausted, yellow smoke comes next, and when the yellow and white smoke is exhausted, blue-green smoke follows.

After being molten down, the alloy was ready for casting:

> 液爰瀉於兜杓，匣遂明於模印。[141]
>
> The melt flows swiftly into the casting ladle and the sand moulds are prepared through the imprint of the matrix [coins].

Coin casting technology in China over the centuries underwent two significant changes.[142] During the earliest period, when metal casting had not developed into an industry of mass production yet, coins were cast in singular, so-called piece moulds (*pingbanfan* 平板範) carved out of clay one by one.[143] Probably still during the Warring States period, however, when output numbers increased, however, the stack casting method (*diezhu* 疊鑄) appeared, which still utilized clay moulds, but now linked up to each other and filled through one common casting gate.[144] This method was in Vietnam still in use during the 19th century.[145] In China, however, already during the 6th century a new method came to be applied, which proved to be most efficient especially in the production of identical or close to identical items and remained in use for the next 13 centuries:

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141 DYF, see chapter X.2p of this thesis.

142 I am thankful to Cao Jin for pointing out these changes to me, she has treated them in detail in her still unpublished paper with the title "Cast in the Sand: Comparative Views on the Chinese Way of Minting before Mechanisation", see Cao Jin (2011).

143 Zheng Jiaxing (1959), p. 68ff; Hua Jueming (1988), p. 38. Zhou Weirong (2002b), p. 199.

144 Zhou Weirong (2002a), p. 13ff.

145 Schroeder (1905).

The method of "sand-casting with mother coins" (*muqian fansha fa* 母錢翻砂法).

This method was consequently also in use during the Song period. It is described by Bowman, Cowell & Cribb most precisely in the following way: "The Coins were cast in large numbers in batches in two-piece moulds arranged vertically. Moulds were prepared from fine sand re-enforced with an organic binder and contained within a wooden box. A pattern of 50-100 "matrix coins" were pressed lightly into the surface and then a second mould box was placed face down on top. An impression was thus taken of both sides of the mother cash pattern. The mould boxes were then turned over and separated so that the matrix coin remained on the lower mould surface. A fresh mould box was then laid on this and again the pair was turned and separated. In this way a series of two-piece moulds were obtained. After clearing out casting channels between the coin imprints and making a central runnel, the boxes were fixed together in pairs and, after a preliminary firing, metal was poured in."[146] A detailed account of this process, which this description is based on, however, can only be found in the *Tiangong kaiwu* from the early 17th century.[147]

After the casting is completed and the molten metal has become solid, the result was a so-called "cash tree" (*qianshu* 錢樹) from which the coins, now still connected through their casting channels, needed to first be separated. The *Daye fu* mentions this as well as further measures of coin treatment after the casting as well:

146 Bowman, Cowell & Wang (1989), p. 5.

147 TGKW / Herrmann, p. 141.

擥之落落，貫之磷磷。磋之以風車之輣軋，轆之以水輪之砰隱。繒網涓拭，蠱覈摩揗。[148]

[The coin trees] are broken up-"luo luo" and [the coins] are pierced [on a stick]-"lin lin". With the squeaking noise of a wind-driven wheel, they are polished; with the crunching sound of a water wheel they are rolled.[Then] they are wiped clean with a silk net and scrubbed with grain chaff.

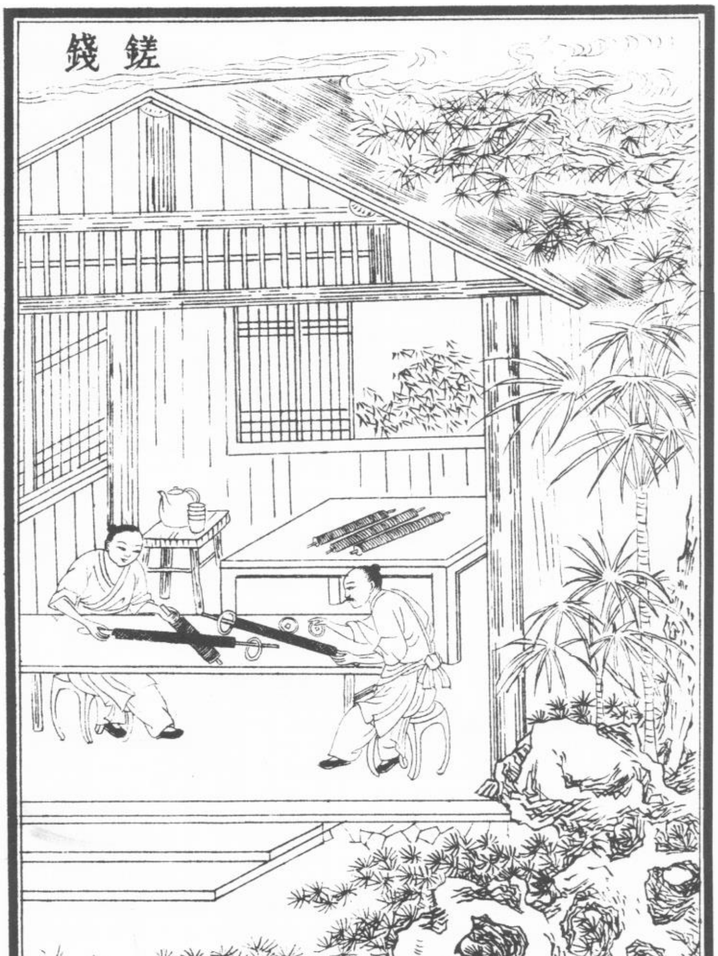

Fig. 18: Filing of freshly cast copper coins, Illustration from the early 17th century. Source: TGKW / Herrmann, p. 147.

148 DYF, see chapter X.2p of this thesis.

This particular passage of the description in the *Daye fu* is very interesting, because it provides hints towards several possible specialties of minting technology during this time. Because of the rather poetic than factual nature of the expression, it can however not be stated clearly that these speculations are true:

1. It is mentioned that the coins were not only "polished" or "filed" (*cuo* 磋), a treatment similar to the one displayed in Fig.18 above, but also "turned" or "rolled" (*lu* 轆). This could mean that the coins were in fact lathed, a technique so far only known from the early Ming period, but then under the name "milling the rim" (*xuanbian* 旋邊), which produced particular smooth, beautiful and forgery-proof coins. In later times, this technique was abandoned because of economic reasons.[149]

2. The noises of a wind wheel (*fengche* 風車) and a water wheel (*shuilun* 水輪) are mentioned. This can be understood in a way that the filing and lathing of the coins produces a sound similar to the one of a wind wheel and a water wheel, but it can also be understood in that way, that during the Song period the Chinese mints actually did employ wind wheels and water wheel to provide energy for the filing and lathing processes. If the second understanding would be true, this would point to a remarkable level of mechanisation in this field. Above all, the appearance in the *Daye fu* may be the earliest mention of a wind wheel in a Chinese text.[150]

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[149] Cao (2011), p. 7; von Glahn (1996), p. 105.

[150] For more details on the early history of wind wheels in China, see Zhang Baichun (2008) as well as a review on this article by the author, Jost (2011).

3. The wiping of the finished coins with a silk net (*zengwang* 繒網) is not mentioned in any other Chinese source from any time period. It can, however, be retraced from a Japanese picture scroll of the mid-18th century (see Fig. 19).[151]
4. It is not clear if the scrubbing of the coins with grain chaff belonged to the standard repertoire of coin finishing, because except for the *Daye fu* only one source from the late Qing period, the "Survey of casting coins" (*Zhuqian shulue* 鑄錢述略) mentions it.[152]

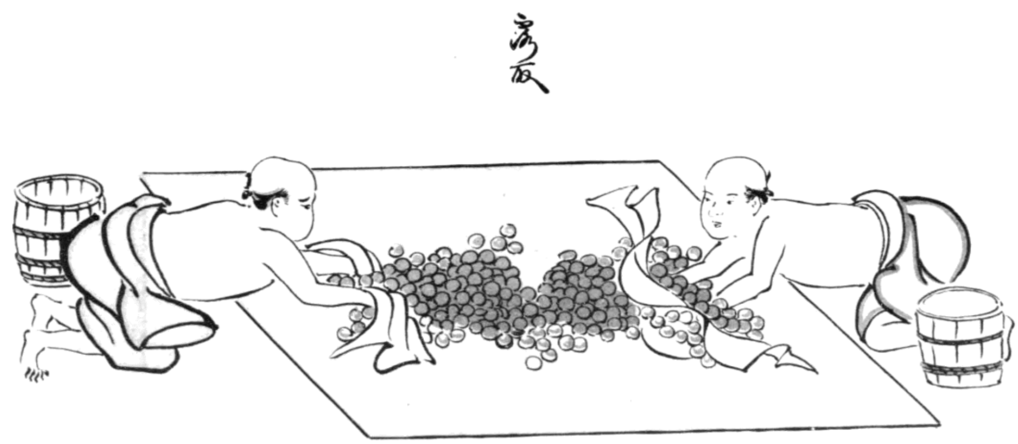

Fig. 19: Wiping newly cast coins with a silk cloth in the Ishimomaki Mint in Japan. Picture scroll from 1924 displaying the situation during the Kan'ei era (1624-43). Source: National Diet Library of Japan.

[151] Cao (2011), p. 6.

[152] Cao (2011), p.5.

After these last steps of polishing, the coins were ready to be brought into circulation. For this purpose, they were first weighed for control and then finally stringed for transport.

> 既刮垢以磨光，始結緡而就准。盡東門之漚麻，不足以為其貫引。[153]
>
> Only after the dirt has been scraped off and they have been polished smooth, are they stringed and brought to the steelyard.All the ret flax at the East Gate is used up, but this is still not sufficient for making all the [required] strings.

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[153] DYF, see chapter X.2p of this thesis.

IV) Copper Soaking Technology

The probably most prominent place to explain how wet copper production by soaking worked, is the official "History of the Song Dynasty" (*Song shi* 宋史) itself. In a downsized remark the process is described most briefly but including all its important steps:

> 浸銅之法
> 以生鐵鍛成薄片，排置膽水槽中浸漬數日，鐵片為膽水所薄，上生赤煤，取刮鐵煤入爐，三煉成銅。[154]

> The method of copper soaking
> Raw iron is forged into thin chips, these are arranged inside a gutter with vitriol water and soaked there for several days. The iron chips become intruded by the vitriol water and produce a red powder on their surface. The powder is scratched down from the iron und entered into a furnace. After three times smelting, it becomes copper.

What sounds simple at first, describes a method whose successful execution requires a great variety of considerations beginning from the correct evaluation of the water over the suitable construction of the facilities, the seasonal differences in operation and many more.

154 SS Chap. 180, Shihuo xia er 食貨下二, Qianbi 錢幣.

1) Identification of suitable waters

The most important requirement for the operation of a copper soaking facility is the existence of natural vitriol water in sufficient amounts. While the term "vitriol waters" represents any aqueous solution containing certain amounts of different copper sulphates, in praxi these fluids can have very different chemical compositions, can contain great numbers of other minerals in solution or can be contaminated with other organic or inorganic substances. These compositions can cause very dissimilar appearances and suitabilities for a use in wet copper production. Besides, especially in the South Chinese mining regions with their particular geological tessellation, what seems be a copper sulphate bearing vitriol water at first, may easily turn out as a completely different sulphate solution of no value at all.

The two most important ways to distinguish and categorize the quality of the rivulets were their looking as well as their taste and smell. It appears that tasting and smelling was a very common way of identifying vitriol waters when its use for wet copper production just began. In his preface to the no longer extent "Outline of copper soaking" (*Jintong yaolüe* 浸銅要略), Zhang Jia 張甲, the son of the possible inventor of industrial wet copper production,[155] tells about his first attempt to find vitriol water for the production of wet copper:

因瞰銅竇，忽見清流，挹而嘗之，氣味俱厚。[156]

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[155] For more detailed information on this book as well as on the Zhang family see chapter VII.2 of this thesis.

[156] JDZSZP / JTYLX(ZJ), p. 40.

> By accident I saw from above a copper hole and a blue-green[157] stream. I ladled out the water and tried it, the smell and taste were both strong.

Identifying the right vitriol water must have required great experience and sensitivity, as the "Rhapsody of the Great Smelting" (*Daye fu* 大冶賦) recounts with reference to two legendary figures famous for their supernatural senses:

> 辨以易牙之口，[…] 鑒以離婁之目，[…][158]

> Distinction is made with a mouth [like the one of] Yi Ya, […] Differentiation is [achieved] with eyes [like the ones] of Li Lou, […]

In the following, different tastes and appearances are listed, which indicate a superior or inferior quality of vitriol waters:

> […] 膽隨味而不同。青澁苦以居上，黃醽而次中。[…] 泛浮漚而異容。赤間白以為貴，紫奪朱而弗庸。[159]

> […] Vitriol [waters] differ with respect to their taste: Blue-green, astringent and bitter, this are the best ones, yellow, juicy and sour, these are next best. […] Foam is floating on the surface with different appearances: Red intermingling with white, these are held to be most precious. Purple dominating over vermilion, these are [also] good to use.

It would be highly speculative to guess the compositions of the respective vitriol waters out of this description, but a blue-green colour would in fact indicate a relatively high copper concentration while a yellow liquid in this context may be likely to contain some more sulphur.

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157 The original source says "clear" (*qing* 清) instead of "blue-green" (*qing* 青), supposably the three-dotted water radical was added at the left wrongly during a later copying, since *blue-green* water would be a typical indicator for some copper sulphates solved in water.

158 DYF, see chapter X.2m of this thesis.

159 DYF, see chapter X.2m of this thesis.

The “Book of Yanshan” (*Yan shu* 鉛書) offers a more detailed view of the situation in the mining region of Yanshan 鉛山, today Jiangxi Province. Besides describing taste and looking of the types of water, the *Yan shu* also attaches different names. Additionally, it is mentioned, how the choice of the vitriol water will affect the colour and quality of the powder appearing at the surface of the soaked iron chips:

> 烹礦分三等：上等，膽水浸，礦紅色；中等，膽礬水浸，礦紫色；下等，黄礬水浸，礦黄色。須三色礦末品搭, […][160]
>
> The ore [powder] for smelting is divided into three levels: The top level [is obtained by] soaking in “gall water“ (*danshui* 膽水), this ore [powder‘s] colour is red; the middle level [is obtained by] soaking in “gall alum water” (*danfanshui* 膽礬水), this ore [powder’s] colour is purple; the bottom level [is obtained by] soaking in “yellow alum water” (*huangfanshui* 黄礬水), this ore [powder’s] colour is yellow. These three colours of ore powder should be mixed [in a certain ratio] according to their quality. […]

Fig. 20: Different examples of vitriol water appearing in the nature in Dexing (left), Yanshan (middle) and Shaoguan (right). Photos by the author.

160 YS, chap. 1, p. 65a.

2) Production Facilities

A) Construction

Once a sufficiently large source of suitable vitriol water has been located, the first important task is, to direct this water to a place, where the territory allows the construction of the gutters for the soaking of iron chips. In the likely case, that one single rivulet is not enough to provide a close to steady water supply, it may be necessary to lead vitriol waters from different directions together to one place. For this purpose, channels and pipes through mountainous landscapes need to be constructed. The *Daye fu* provides a vivid, though probably somewhat literarily exaggerated impression of what these channels and pipes may have looked like:

> 陂沼既潴，溝遂斯決。瀺灂澒溶，汩潒澂洌。銅雀台之簷霤，萬瓦建瓴而淙淙。龍骨渠之水道，千澮分畦而潏潏。[161]
>
> Pools and ponds full of water, bursting through gutters and channels; sputtering and gurgling, the water, stretching deep and wide; flowing fast, with waves beating each other; [like] the stream of water from the eaves of the Copper Sparrow Platform, rushing in the channels formed by ten thousand tiles, [like] the waterway of the Dragon-Bone-Channel, sputtering in one thousand ditches and distributing to the parterres.

According to the *Yan shu* every copper soaking facility or "place" (*chu* 處) gathers the vitriol water it obtains like this from the springs and rivulets on the copper mountains first in a reservoir or "pond" (*chi* 池)[162] before it

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[161] DYF, see chapter X.2m of this thesis.

[162] YS, chap. 1, p. 64b.

continues to flow into the gutters, where the iron chips are soaked. The arrangement and construction of these gutters is described as follows:

> 隨地形高下深淺，每一池或二三溝，或至十余溝。用板就地裝匝，鋪茆席襯內，[…][163]
>
> According to the respective topographical setting, [with its] high or low [mountains] and deep or shallow [valleys], to each pond may belong two to three gutters or even up to more than ten gutters (*gou* 溝). Wooden boards are installed around on the ground, then straw mats are laid out on the bottom.

The text relates that in Yanshan during the time of its compilation 77 "places" were soaking copper encompassing 230 "grooves" (*cao* 槽).[164] In another passage all together 76 "gutters" (*gou* 溝) are listed and grouped according to the type of vitriol water they use for production. This number suggests, that the term "gutter" could be used for a production unit of averagely three "grooves" and thus be synonymous with "place". In other contexts, however, "gutter" can still stand for a single small water channel.

B) Names of Production Facilities

The "gutters" listed in the *Yan shu* by name allow a great number of inferences to many aspects of construction, location and arrangement of copper soaking facilities:

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[163] YS, chap. 1, p. 64b.

[164] YS, chap. 1, p. 64b.

Table 3: “Gutters” (*gou* 溝) in Yanshan according to the *Yan shu*[165]

#	Chinese Name	English Name	Type of Water	Type of Name
1	*Chawu gou* 碴塢溝	Crumb basin gutter	gall alum water	geogr. location
2	*Chenjia shan gou* 陳家山溝	Gutter on the “Chen family’s mountain”	yellow alum water	personal name geogr. location
3	*Chen Yaofu gou* 陳堯富溝	Chen Yaofu’s gutter	yellow alum water	personal name
4	*Dai Tian gou* 戴添溝	Dai Tian’s gutter	yellow alum water	personal name
5	*Dasheng quan gou* 大聖泉溝	Great sage spring gutter	yellow alum water	auspiciousness
6	*Dongjia wu gou* 董家塢溝	Gutter at the “Dong familiy’s basin”	gall water	personal name geogr. location
7	*Fanchang gou* 礬場溝	Alum mine gutter	yellow alum water	mining
8	*Fanchang yushui gou* 礬場余水溝	-Alum mine extra water gutter	yellow alum water	
9	*Fengguo gou* 豐國溝	Thriving country gutter	gall alum water	auspiciousness
10	*Fucai gou* 傅才溝	Fu Cai’s gutter	yellow alum water	personal name

165 YS, chap. 1, pp. 64a-64b.

11	*Fu Cai xia gou* 傳才下溝	Fu Cai's lower gutter	yellow alum water	
12	*Fu Cai yushui gou* 傳才余水溝	Fu Cai's extra water gutter	yellow alum water	
13	*Fuxing gou* 復興溝	Returning prosperity gutter	yellow alum water	auspiciousness
14	*Fuxing quan gou* 福興泉溝	Lucky prosperity spring gutter	gall alum water	auspiciousness
15	*Zhuji long **Fu** Yan xin gou* 祝機瀧傳偃新溝	Fu Yan's new gutter in the Zhuji gorge	yellow alum water	personal name geogr. Location
16	*Fu Yan zhong gou* 傳偃中溝	Fu Yan's middle gutter	yellow alum water	personal name
17	*Fu Yan yu gou* 傳偃馀溝	Fu Yan's extra gutter	yellow alum water	
18	*Guan zhi gou* 官置溝	Officially established gutter	gall water	other
19	*Gukeng quan gou* 古坑泉溝	Gutter by the old pit at the spring	gall water	mining
20	*Gukeng qian xin zhi gou* 古坑前新置溝	Newly established gutter in front of the old pit	gall water	
21	*Jiaoshi kan gou* 礁石埳溝	Rock cavity gutter	yellow alum water	geogr. location
22	*Jubao quan gou* 聚寶泉溝	Assembling-treasures spring gutter	yellow alum water	auspiciousness

23	*Jubao yushui gou* 聚寶余水溝	Assembling-treasures extra water	yellow alum water	
24	*Kaishanmen gou* 開山門溝	Mountain-opening-gate gutter	yellow alum water	geogr. location
25	*Lijia yuan da gou* 李家源大溝	Great gutter at the “Li family’s source”	gall water	personal name spring or water
26	*-da xin gou* -大新溝	-great new gutter	gall water	
27	*Lü Cheng shang gou* 呂承上溝	Lü Cheng’s upper gutter	yellow alum water	personal name
28	*Maojia yu gou* 毛家畲溝	Gutter in the “Mao family’s fields”	yellow alum water	personal name geogr. location
29	*Men qian gou* 門前溝	Gutter in front of the gate	yellow alum water	shape or place
30	*Nanshan shang gou* 南山上溝	Upper gutter at the South Mountain	gall alum water	geogr. location
31	*Nanshan zhong gou* 南山中溝	Middle gutter at the South Mountain	gall alum water	
32	*Nanshan xia gou* 南山下溝	Lower gutter at the South mountain	yellow alum water	
33	*Nan shan xin gou* 南山新溝	New gutter at the South mountain	yellow alum water	

34	*Nanshan bian gou* 南山邊溝	Side gutter at the south mountain	yellow alum water	
35	*Nantai gou* 南臺溝	Southern terrace gutter	yellow alum water	geogr. location
36	*Qingshui quan gou* 清水泉溝	-blue-green water spring gutter	yellow alum water	spring or water
37	*Qushe gou* 曲蛇溝	Crooked [like a] snake gutter	yellow alum water	shape or place
38	*Shao Zhongji gou* 邵忠積溝	Shao Zhongji's gutter	gall water	personal name
39	*Da shengshui gou* 大生水溝	Great raw water gutter	gall alum water	spring or water
40	*Da shengshui yushui gou* 大生水余水溝	Great raw water gutter for extra water	gall alum water	
41	*Xiao shengshui gou* 小生水溝	Small raw water gutter	gall water	
42	*She shang gou* 舍上溝	Gutter above the house	yellow alum water	shape or place
43	*She xia gou* 舍下溝	Gutter below the house	yellow alum water	
44	*Suoshanmen gou* 鎖山門溝	Mountain-closing gate gutter	gall alum water	geogr. location
45	*Tang Yuande shang gou* 唐元德上溝	Tang Yuande's upper gutter	yellow alum water	personal name
46	*Tongshan gou*	Copper mountain	yellow alum	mining

	銅山溝	gutter	water	
47	*Tucha shang gou* 土碴上溝	Upper earth crumbs gutter	yellow alum water	mining
48	*Tucha xia gou* 土碴下溝	Lower earth crumbs gutter	yellow alum water	
49	*Tuzhai gou* 土窄溝	Earth crumbs gutter	gall water	shape or place
50	*Wang Zhi shang gou* 王智上溝	Wang Zhi's upper gutter	yellow alum water	personal name
51	*Wang Zhi xia gou* 王智下溝	Wang Zhi's lower gutter	yellow alum water	
52	*Wen Zicong gou* 問子從溝	Wen Zicong's gutter	yellow alum water	personal name
53	*Xiakou gou* 峽口溝	Gutter at the gorge entrance	yellow alum water	geogr. location
54	*Xiakou xin zhi gou* 峽口新置溝	Newly established Gutter at the gorge entrance	yellow alum water	
55	*-xin zhi gou* -新置溝	-newly established gutter	yellow alum water	
56	*-xin zhi xia gou* -新置下溝	- newly established lower gutter	yellow alum water	
57	*Xiguan gou* 西關溝	West pass gutter	gall alum water	geogr. location
58	*Xin xing gou* 新興溝	New prosperity gutter	gall water	auspiciousness
59	*Xin xing quan gou*	New prosperity	gall alum	

	新興泉溝	spring gutter	water	
60	*Xing sheng gou* 興勝溝	Prosperous victory gutter	yellow alum water	auspiciousness
61	*-xin zhi gou* -新置溝	- newly established gutter	yellow alum water	
62	*Yang Wenwei gou* 楊文維溝	Yang Wenwei's gutter	gall water	personal name
63	*-xiao xin gou* -小新溝	-small new gutter	gall water	
64	*Yao Jia da gou* 姚價大溝	Yao Jia's great gutter	yellow alum water	personal name
65	*Yao Jia xin gou* 姚價新溝	Yao Jia's new gutter	yellow alum water	
66	*-xin gou yushui gou* -新溝余水溝	- new gutter's extra water gutter	yellow alum water	
67	*Yao Jia xin zhi gou* 姚價新置溝	Yao Jia's newly established gutter	yellow alum water	
68	*Yao Tong gou* 姚峂溝	Yao Tong's gutter	gall alum water	personal name
69	*-Xin zhi gou* -新置溝	-newly established gutter	gall alum water	
70	*Yu cheng gou* 余成溝	Yu Cheng's gutter	gall alum water	personal name
71	*Zhang Neng gou* 張能溝	Zhang Neng's gutter	yellow alum water	personal name
72	*Zhang Neng bian gou*	Zhang Neng's side gutter	yellow alum	

	張能邊溝		water	
73	*Zhushiling gou* 硃石嶺溝	Vermilion rock peak gutter	yellow alum water	geogr. location
74	*Zhuyewu xin gou* 竹葉塢新溝	New gutter at Zhuyewu	gall alum water	geogr. location
75	*Zhuye da gou* 竹葉大溝	Great gutter at Zhuye[wu]	gall alum water	
76	*Zhuye zhong gou* 竹葉中溝	Middle gutter at Zhuye[wu]	gall alum water	

Firstly, it appears, that the names of all the "gutters" around Yanshan can be divided into certain categories, these are:

1. **Personal Names**
   Names of individuals or families owning a production facility or being entrusted with their operation by the government.

2. **Geographical Locations**
   Names reflecting landscape forms, geological phenomena or other place names derived from such.

3. **Auspiciousness**
   Names reflecting hopes and wishes attributed to the production facility, usually from the semantic field of material wealth.

4. **Shape or Place**
   Names referring either to constructional particularities or aspects of the very detailed location of the production facility

5. **Mining**
   Names pointing to other mining-related locations in the vicinity of a production facility.

6. **Spring or Water**

   Names directly derived from the source or other characteristics of the water used for soaking in the respective facility.

7. **Other**

The chart below counts place names appearing several times (e.g. "Fu Cai's upper gutter" and "Fu Cai's lower gutter") only once.

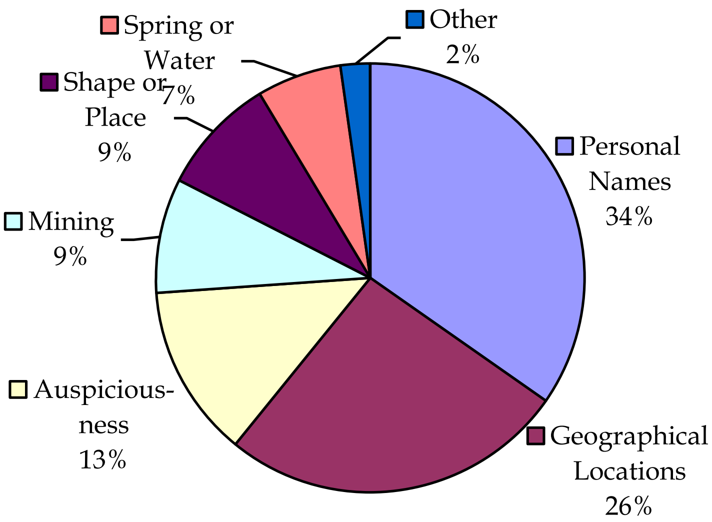

Chart 1: Categories of place names for "gutters" (*gou* 溝) in Yanshan

Besides the names of the facilities themselves, diversification inside one set of "gutters" provides some information as well: all together six different types of gutters can be identified from the list, those are:

1. **Extra water Gutter (*yushui gou* 余水溝)**

   This type of gutter may have been installed either if the amount of vitriol water at a gutter constantly or at certain times exceeded the capacity of the existing gutter.

2. **Upper Gutter (*shang gou* 上溝)**

   If along one water channel several gutters are situated, this should be the one upstream, consuming the fresh vitriol water.

3. **Lower Gutter (*xia gou* 下溝)**

   If after flowing through one gutter the water still contains a certain amount of copper, another gutter maybe established downstream.

4. **Middle Gutter (*zhong gou* 中溝)**

   If appearing in combination with another upper gutter or lower gutter, this may be a third gutter along one channel in the middle. If appearing together with a great or a small gutter, it may refer to the size.

5. **Spring Gutter (*quan gou* 泉溝)**

   Not for sure a category for itself, in some cases probably the one from a set of gutters located closest to the vitriol spring.

6. **Side Gutter (*bian gou* 邊溝)**

   It cannot be known what this gutter was used for, it probably bypassed a larger gutter at the side and provided relief for periods of strong vitriol water flow like the Extra water gutter.

The frequency, in which these categories can be encountered in the list, creates a picture as displayed in chart 2:

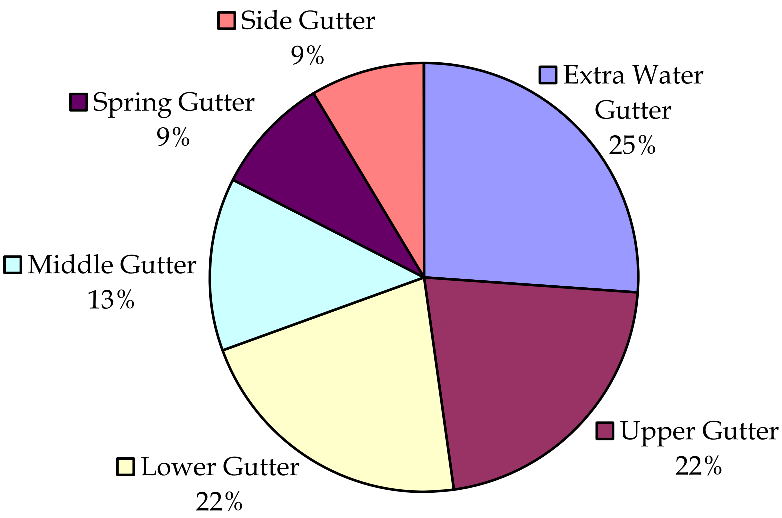

Chart 2: Types of special "gutters" (*gou* 溝) in Yanshan

Interestingly, there are two "upper gutters" which appear without "lower gutter" and in turn two "lower gutters" which appear without "upper gutter". The difference is that besides every existing "lower gutter" at least one other gutter with the same name can be found, while the two "upper gutters" are isolated with no namesakes in the list. This may lead to the assumption, that, when the owner of one single gutter noticed that the water flowing out of his facility was still of a sufficient quality for further use, established a new "lower gutter" downstream but did not change the name of his old gutter. The operator of a facility consisting in an "upper gutter" and a "lower gutter" in turn may have taken his "lower gutter" out of service as soon as the water quality was not sufficient to satisfy the demand of two gutters any more.

It can be observed, that none of the twelve places working with the highly estimated "gall water" encompasses any combination of upper, middle and lower gutters, while. Of 16 gutters supplied with the secondary level "gall alum water", only two (12.5%) are named "upper" or "lower". The lion's share of eight such gutters is located among the inferior 48 "yellow alum water" gutters (16.8%). The reason for this may be, that with the high quality "gall water" the replacement reaction took place much faster and more complete than with the two waters of lower quality, leaving no sufficient copper content in the effluents to allow another round of soaking downstream.

Another source providing us with information on the names of wet copper production facilities is a preface to the already mentioned *Jintong yaolue* written as late as 1352 under the Yuan Dynasty but probably quoting the book itself, which was compiled in 1094. The text does not list gutters but "springs" (*quan* 泉), a term which in the direct context of production facilities does not appear in the *Yan shu*. The "springs" around the Xingli 興利 mine in the area of the present-day city of Dexing 德興 in Jiangxi Province are classified according to their vitriol water's quality in three levels as well but not by mentioning the type of water. Instead the number of days a piece of iron needs to be soaked before washing the copper off its surface is recorded.

Table 4: "Springs" (*quan* 泉) near Xingli according to Wei Su[166]

#	Chinese Name	English Name	Washing frequency	Name type
1	*Chen Jun lu qian* 陳軍鑪前	In front of Chen Jun's furnace	10 days	mining
2	*Da nanshan* 大南山	Great South mountain	10 days	geogr. location

166 WTPJ / JTYLX (WS), chapter 10, p.11f.

3	*Dayan* 大巖	Great Cliff	7 days	geogr. location
4	*Shang **d**ongshan* 上東山	Upper East Mountain	7 days	geogr. location
5	*Xia **d**ongshan* 下東山	Lower East Mountain	7 days	
6	*Dongshan nanpan* 東山南畔	Southern side of the East Mountain	7 days	
7	*Shang **He** Mu* 上何木	Upper He Mu	10 days	personal name
8	*Zhong **He** Mu* 中何木	Middle He Mu	10 days	
9	*Xia **He** Mu* 下何木	Lower He Mu	10 days	
10	*Hengcha wu* 横槎隖	Level branches basin	10 days	geogr. location
11	*Hengcha xia wu* 横槎下隖	Level branches lower basin	10 days	
12	*Hengquan* 横泉	Level spring	7 days	spring or water
13	*Huangniu* 黄牛	Yellow buffalo	5 days	animal
14	*Huangshan* 黄山	Yellow mountain	7 days	geogr. location
15	*Jiaoyuan* 焦原	Burnt plateau	10 days	geogr. location
16	*Leng jin* 冷浸	Cold soaking	10 days	functional
17	*Qiguan wu* 齊官隖	Qiguan basin	7 days	geogr. location

18	*Qingshan* 青山	Blue-green mountain	7 days	geogr. location
19	*Tongji* 銅積	Copper Assembler	10 days	functional
20	*Shang shigu* 上石姑	Upper Stone Woman	7 days	geogr. location
21	*Xia shigu* 下石姑	Lower Stone Woman	7 days	
22	*Shiqiang wu* 石墻隖	Stone wall basin	7 days	geogr. location
23	*Shang tanzao* 上炭竈	Upper Charcoal kiln	10 days	mining
24	*Xia tanzao* 下炭竈	Lower Charcoal kiln	10 days	
25	*Xiwu* 西隖	West basin	10 days	geogr. location
26	*Xiao nanshan* 小南山	Little South Mountain	7 days	geogr. location
27	*Yangzhan* 羊棧	Goat hutch	10 days	animal
28	*Yao Min* 姚旻	Yao Min	10 days	personal name
29	*Shang Yao Min* 上姚旻	Upper Yao Min	10 days	
30	*Xia Yao Min* 下姚旻	Lower Yao Min	10 days	
31	*Yongfeng* 永豐	Eternal abundance	7 days	auspiciousness
32	*Zhangmu yuan* 章木原	Zhangmu plateau	7 days	geogr. location

The thematic distribution of the spring names shows much less variety than in the case of the gutters in Yanshan. Their vast majority obviously are not even real names but rather descriptions of their location in relation to other landmarks. The reason for this may be, that the preface is in fact obtaining its information from the book itself, which was written at a time, when wet copper production in the region was just about to be established. Most of these sources were probably largely unknown to the population and the information on their location and water quality had just been obtained in the course of prospection and trial soaking. Clearly an exception to this are the "Eternal abundance" spring with a name obviously indicating the production of wealth, the "Copper assembler" spring with a likewise evident connotation and the "Cold soaking" spring.

C) Water control

One very important difficulty of copper soaking was the great dependence on a stable supply of vitriol water with a sufficient quality. Generally speaking, big amounts of rainfall are helpful for this, because they provide enough water to leach the copper sulphate bearing layers of a mountain and to keep a steady stream of vitriol water running. Thus the *Yan shu* relates:

> 洗，自四月至七月為熱月，全藉此時膽水生發，[…]大率春夏之交，三雨兩晴，雷震泉動，則其水湧盛濃釅，浸礦易收。[167]
>
> For washing, the fourth to the seventh month are the "hot months". It is only counted on these months that the vitriol water can procreate and develop, […] Generally speaking, at the turn of spring to summer, the weather is an alternation of three days rain and two days sunshine, thunders roll and springs pour. Thus the water gushes in abundant

167 YS, chap. 1, p. 65a.

amounts and with an intensive taste. This brings easily good results in ore soaking.

While abundant rainfall usually offers great conditions for copper soaking, a too high amount of rain can easily lead to opposed results. If the water in the channels overtops their banks it can easily become contaminated with too much other materials and thus not suitable for precipitation any more. In the worst case, floods or mudslides from the mountains would make working impossible and eventually destroy the facilities.

Fig. 21: New year's wishes at the door of a dwelling besides a present-day copper soaking facility in Yanshan. The Characters read "From four sides falls rain / from eight directions comes wealth / what you wish with your heart will be fulfilled." Photo by the author.

If rainfall is not sufficient to the opposite, not only the water supply decreases easily to a level that copper soaking will easily turn uneconomic, the composition of the fluid can also change in a way making operation impossible or at least requiring additional measures:

[…]八月至三月為冷月，則膽漸退，所浸不澄。[…]若春夏闕雨，溝槽間所浸鐵料，皆生黄漿，即須併溝作水排浸 […][168]

[…] The eighth month to the third month [of the next year] are "cold months", during which the vitriol gradually retreats, thus the result of the soaking cannot settle. […]If the rain is scarce during spring and summer, the iron material soaked in the grooves and gutters will produce a yellowish thick liquid. In this case, one has to join the gutters together to increase the water draining and soaking. […]

In order to ensure a steady flow of vitriol water through the grooves strong enough to lead to satisfying production result but at the same time preventing harmful overflowing of the facilities, it was necessary to establish a deliberate system of water flow regulation. This was carried out firstly by establishing ponds to collect vitriol water and thus creating a storage from which water could continue to flow for a while when the natural streams were already drying out. Secondly as the *Daye fu* describes

量深淺以施槽，隨踈密而制閘。陸續吞吐，蟬聯貫列。[169]

The depth is measured to construct grooves, and according to the distance sluice gates are built. Swallowing and spouting in succession, stretching along and arranged in good order.

Precise control of the water level in the grooves was achieved by installing sluice gates which only allowed as much water as needed to enter. Like this, if the arriving amounts of water were too large for the grooves they could either be retained, drained off through another channel or- in the best case- passed on to an extra water gutter (*yushui gou* 余水溝).

A very interesting investigation has been undertaken by Li Zhongjun 李仲均, in which he contrasts the output of wet copper during the entire

168 YS, chap. 1, p. 65a.

169 DYF, see chapter X.2m of this thesis.

Song period with indication concerning rainfall in local gazetteers. He comes to the conclusion, that high rainfall was crucial to a successful production of wet copper, which even leads him to the assumption that the success of wet copper production during the Song period may only have been possible because during this time especially in the concerned regions of Jiangxi more rain fell than during any other period of Chinese history.[170]

3) Production Process

A) Inserting of Iron

Once gutters with a controlled vitriol water supply were prepared, iron could be entered into them in order to be soaked. Apparently at first cheaply available scrap iron was used, only later, when production numbers increased to an extent that by this a steady supply could not be ensured any more, iron works began to produce iron only for the purpose of soaking. The *Daye fu* describes the inserting of iron into the gutters in the following way:

> 乃破不轑之釜, 乃碎不湘之錡, 如鱗斯布，如翼斯起。[171]
>
> Then pans not used for frying any more are smashed, and pots not used for cooking any more for are broken. Spread there like fish scales and protruding like flippers.

[170] Li Zhongjun (1987).

[171] DYF, see chapter X.2m of this thesis.

The image of fish scales for the arrangement of the iron pieces not only appears in the *Daye Fu*, the *Yan shu* uses it in the same way, implying that this expression was less of a literary image than rather a technical term:

> 次碎生鐵鍋片入溝，如魚鱗排砌，然後引水通流浸灌。[172]
>
> The next step is to break up cast iron woks, to put the pieces into the gutters and arrange them in the shape of fish scales. Then one diverts the vitriol water to run through them and [lets the iron become] soaked in it.

When describing the process seemingly by using fresh cast iron instead of scrap, the *Song huiyao jigao* employs the same picture:

> 浸銅之法
> 先取生鐵打成薄片，目為鍋鐵，入膽水槽，排次如魚鱗，浸漬數日。[173]
>
> The method of copper soaking
> First one takes cast iron and beats it into thin pieces, which are called "pot iron". They are put into the water groove, arranged like fish scales and soaked for several days.

If calling the arrangement of the iron pieces in the groove "fish scales" was in fact an established technical expression, this should lead to the assumption that the arrangement really must have followed the pattern of a fish's scales, which can be imagined in the following way:

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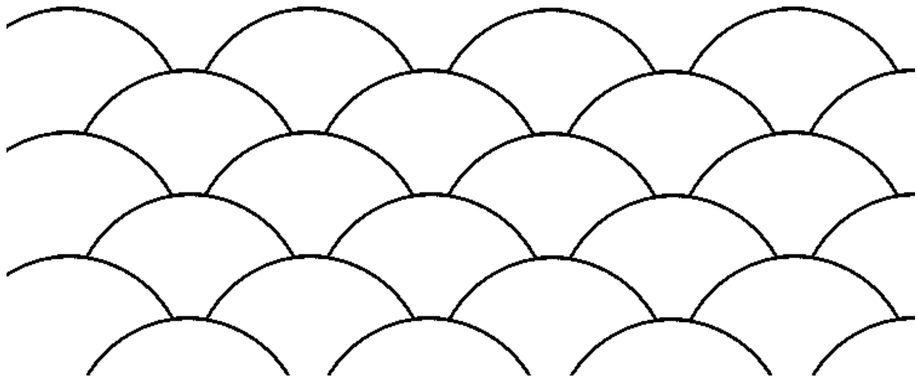
172 YS, chap. 1, p. 64b.

173 SHYJG/ SH chapter 11 (*zhuqianjian* 鑄錢監), p. 3.



The shape of fish scales as to be commonly imagined.

In the chapter about the copper leaching method, which mentions a fish scale shaped arrangement as well, the *Yan shu* describes the iron pieces as having a diameter of five to six *cun*[174] (16-19 cm). The standard measures of a groove in turn are reported to be eight *chi* (251 cm) in length, one *chi* five *cun* (47 cm) in width and seven *cun* (22 cm) in depth. If it can be assumed, that the arrangement practices in copper leaching and copper soaking were the same, that the indicated measures are roughly correct and that they actually represent a general standard established for the purpose of executing the process most efficiently, this would allow certain conclusions to the actually practiced arrangement in detail.

As the *Daye fu* mentions, the iron pieces were not only "arranged like fish scales" but also "protruding like flippers". This means that they somehow must have been standing inside the groove rather than being simply laid out. It is possible to imagine that the bamboo mat at the bottom of the groove already contained fixtures for this purpose, that other appliances for this were inserted into the gutter or that the iron pieces were forged into a shape which allowed them to be standing from

174 For all the measures used in this passage see Qiu Guangming et al. (2001).

the very beginning. To install the iron pieces standing rather than laying, however, makes sense, because only like this all the vitriol water passing the groove would get in contact with iron, while otherwise the upper portion of the water would almost certainly flow away without having precipitated. Consequently, also modern copper soaking facilities use iron in shapes being able to fill the entire space inside the groove rather than only covering its ground. Other than described by the *Yan shu*, these are usually spiral-shaped threads from the recycling plant (see Fig. 22).

Fig. 22: Spiral-shaped iron threads from a modern copper soaking facility in Yanshan, Jiangxi Province. Photo by the author.

This assumption fits well with the measures of the iron pieces and the grooves: While a standing iron piece would have been up to 19 centimetres high, the depth of a groove was 22 centimetres, leaving three centimetres for the vitriol water to flow over the highest pieces without making the groove overflow.

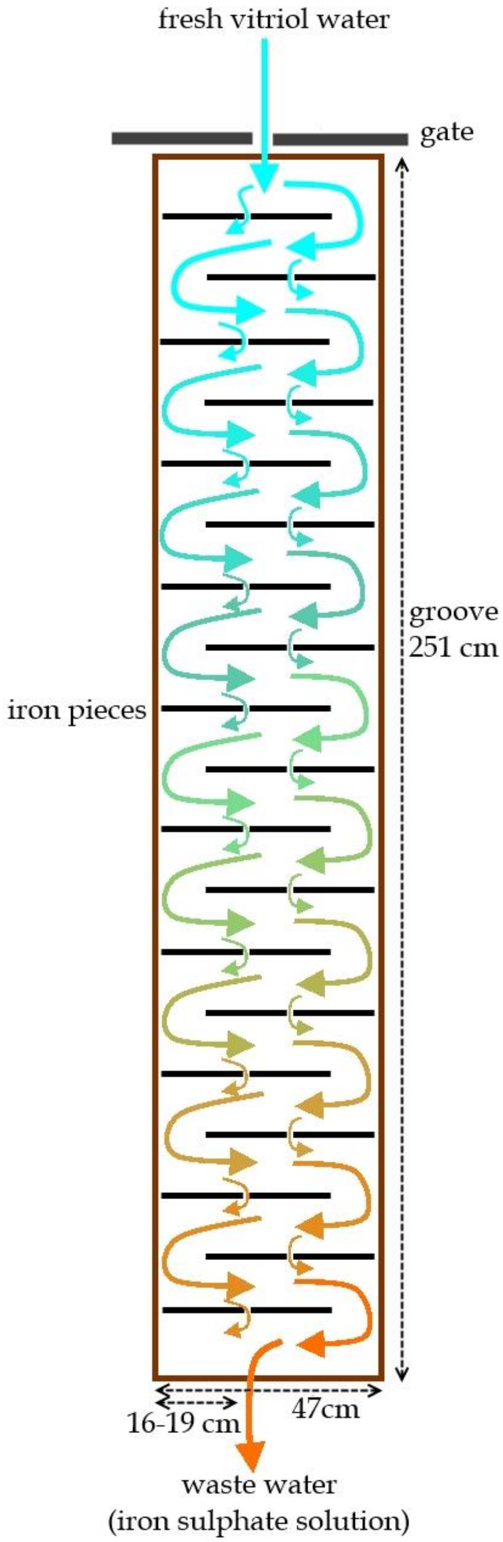


Fig. 23: Scheme to illustrate the arrangement of iron pieces in the groove. The changing colour of the water represents the replacement of copper by iron.

Concerning the horizontal arrangement, it meets the eye that exactly two and a half of the biggest iron pieces could fit beside each other into the groove, allowing the pieces of two rows to be placed overlapping each other exactly by half of their diameter – just like fish scales. The technical advantage of such an arrangement would have been that it would have enabled the iron pieces to force the water to constantly change its flowing direction. By doing so, the velocity of flow could be reduced giving the reaction much more time to take place and thus increase the efficiency of production. Bigger iron pieces as wide as two pieces of the size mentioned by the *Yan shu* would probably have been more difficult to obtain from scrap, could not have been round or square-cut any more without requiring much deeper grooves and would probably have dammed the water making the flow unsteady or letting the grooves overflow (see Fig. 23).

B) Washing

After opening the gate, the iron pieces in the grooves were soaked in the slowly flowing vitriol water for several days until their entire surface was transformed into copper. This copper could appear in the form of a powder sticking to the iron pieces and eventually forming a kind of mud when mixed with the surrounding water. The number of days which had to elapse until this result was reached varied greatly and was before anything due to the quality of the used vitriol water. While most sources confine themselves to mention a period of "several days", in his preface to the above mentioned *Jintong yaolüe*, Wei Su 危素 classifies vitriol water springs in the Xingli mining area according to the required soaking time, reaching from five to ten days.[175] It is however not completely clear, which time period Wei Su is referring to. Due to the exhaustion of deposits it appears that the quality of the vitriol water declined in some places as for instance the Yan shu relates about the situation in Yanshan:

> 舊二日一洗，次五日至七日；今溝槽年深，水味淡薄，並十日方能循環舉洗。[176]
>
> In the old times, washing took place every two days, later it became every five to seven days. Now the grooves and gutters [have been in operation] over many years and the water's taste has become weak. Only every ten days can one washing process start circulating [through each of the grooves].

Whenever the precipitation of copper on the surface of the iron pieces was completed and the according amount of iron had become solved in the water, the iron pieces were taken out of the grooves to be washed and thus to obtain the result in the shape of mud or powder. This process must have been extremely labour-intensive as the *Yan shu* reports:

> 日合千人，部轄兵匠，用小籮運鐵於大桶楻內濯洗，礦末澄澱，復用桶運入場，余鐵再排浸溝內。[177]
>
> One thousand people gather every day, soldiers and craftsmen, and use small bamboo baskets to transport the iron to big barrels to wash. When the ore powder sinks down, the barrels will be used again to deliver it to the smelter, while the rest of the iron will be soaked inside the gutters again.

175 WTPJ / JTYLX (WS), chapter 10, p.11f. For the list of springs in detail see Table 4.

176 YS, chap. 1, p. 65a.

177 YS, chap. 1, p. 65a.

Fig. 24: Washing iron in a copper soaking facility in Yanshan today (I): a.) Washing Tools: Barrel, basket and broom. b.) Soaked iron with vitriol water in it is shovelled into the basket. c.) The water with the rinsed off copper powder in it is shaken in the basket and seeps through into the basket. Photos by the author.

Fig. 25: Washing iron in a copper soaking facility in Yanshan today (II): d.) The washed iron is returned into the grooves. e.) The paste consisting in water and copper powder is cleaned from remaining pieces of dirt and iron. f.) As a result, copper mud is obtained and packed into sacks. Photos by the author.

According to this passage, the copper powder was obtained from the surface of the iron pieces by removing them from the groves and washing them in separate water barrels. This method resembles closely the practice which can be observed in present-day copper soaking facilities in Yanshan with the difference that the spiral-shaped iron used today is not suitable to be washed piece by piece but instead is rinsed by the vitriol water surrounding it in the groove (see Fig. 24c). As the *Yan shu* notes, after being washed off inside the barrel, the copper which is at first mixed with the water slowly sinks down. After several hours it forms a muddy paste at the bottom of the barrel while the upper portion of the water becomes relatively clear again and can be returned to the grooves where the iron pieces with blank surfaces already continue to soak.

The *Daye fu* describes this central part of the production process somewhat differently:

> 漱之瓏瓏，濺之齒齒。沉涵極表以俱暢，蒸釀窮日夜而不止。元冥効其巧譎，陽侯獻其恠詭。變蝕為沫，轉澁為灩 。或浹下簟，自凝珠蕊。且濯且漸，盡化乃已。[178]

> They are rinsed “long-long”and splashed “chi-chi”. Soaked and immersed, they are penetrated from outside to inside; incessantly steaming and fermenting, day and night. […] [Iron] is corroded and changed into foam, and the rough taste turns into a smooth one. If seeping through a bamboo mat, all by itself [copper] coagulates to beads and balls. Washing and imbuing [continues] until each and everything has been transformed.

Compared to the version in the *Yan shu* and the practice in present-day production facilities, this is somewhat difficult to understand: Firstly, the text mentions actions of “steaming” (*zheng* 蒸) and “fermenting” (*niang* 釀), secondly it describes the separation of water and copper powder not

[178] DYF, see chapter X.2m of this thesis.

as a sinking or sedimenting but as a "coagulating to beads and balls" (*ning zhu rui* 凝珠蕊). This may have four possible reasons probably implying alternative ways of carrying out this particular step of production:

1. The *Daye fu* is a work of poetry and thus committed not only to technical precision but also to the inclusion of visual impressions and elegant language. On hot, sunny days in southern China the grooves may in fact have appeared steaming, the vitriol water in the course of the replacement reaction may have given the impression of fruit juice for instance fermenting to become alcohol. "Beads and balls" with their resemblances to precious jewellery or the like carry a more poetic undertone than "ore powder".
2. Although no other source mentions anything like this, in order to directly obtain copper powder and not copper mud, sedimenting and drying of the copper was accelerated by gently heating the barrels, which surely would have produced steam and probably also bubbles resembling a fermenting process.
3. Like in modern Biohydrometallurgy, the advantages of using bacteria in precipitation reactions was already known to people, though not explicitly recorded in any other source. This could have easily resulted in fermenting phenomena in the washing water, it probably may even have required the application of warm water for washing explaining the steam.

Hong Zikui is intentionally or unintentionally mixing up two different methods of wet copper production probably both known to him: The usual method for large scale production as addressed by the *Yan shu* as well and the old secret method of the Daoists as with much detail described in the *Longhu huandan jue*.[179] According to this old secret method, copper would have been produced on a very small scale inside of an iron cooking pot, which would be heated and thus produce steam. During the process, mercury would be added in order to bind the precipitating copper by amalgamation in fact into the shape of beads and balls, which in the end could have been filtered out using a bamboo mat.

C) Smelting

The copper mud or copper powder obtained through the washing of the iron pieces can contain up to some 70-80% of copper but it is, however, not in a suitable shape for further treatment yet and in any case always contaminated with various other materials. Therefore, refining it by smelting is inevitable. The most detailed description of this smelting process is contained in the *Yan shu*. Here it is related that first copper powders obtained from the three different quality levels of vitriol water need to be mixed, supposedly because the low quality ones alone do not qualify for smelting due to their high contents of iron and sulphur. After that

> […] 用木炭燒焙，卻入爐烹煉，方成淨銅。如粗惡，則再留。每銅一斤，約用炭五六斤，烹到三千斤，或四五千斤，即起綱赴監。[180]
>
> […] Wood and charcoal are used to heat them on a small flame, then they are put into the furnace to be smelted, only after that they become pure copper. If [the material] is still crude, it should be roasted again. Every *jin* of copper requires five to six *jin* of charcoal. As soon as three thousand to five thousand *jin* of copper are obtained, one should take off and deliver it to the industrial prefecture.

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179 ZTDZ / LHHDJ, chap. 2. For a detailed discussion see chapter VII.1 of this thesis.

180 YS, chap. 1, pp. 65a-65b.

The fact that wood and charcoal were first used together to heat them up to a rather low temperature implies, that before the actual smelting, the material was roasted to get rid of some of the contained sulphur. It is not clear, if by this time the powder was still moist and the heating also served the purpose of drying or if it was already dried before. However, if it did not react to the smelting as expected, roasting and smelting were repeated. These usually no more than two rounds of smelting seemed to still be remarkably less than for the conventional method of copper production by directly roasting and smelting ore stones. Further discussion on the efficiency of the method can be found in chapter VI.2 of this thesis.

Fig. 26: Copper ingot produced in Censhui during the Song period, supposedly wet copper. This ingot must have been lost during water transport because it was retrieved on the ground of the Zhangshui 章水 river near Nankang 南康, Jiangxi Province. Size: ca. 20 x 10 x 6 cm, Weight: ca. 6 kg.
Source: Private photograph by Song Huiqun 宋會群, Shaoguan University, Guangdong Province. Many thanks to Prof. Song.

V) *Copper Leaching Technology*

The copper soaking method made use of copper sulphate solutions appearing in the nature, usually created by rain waters and underground flumes leaching out suitable deposits of soils and weathered ores. This method thus resembled other modern and pre-modern methods of *in situ* leaching, where the material to be leached out remained in its original place, while water was applied to it in order to obtain the leachate. The exploitation of salines by pumping water into underground salt deposits would be another popular example for such a method.

The copper leaching method turned this process around: Not the production facilities were moved into the courses of vitriol water rivulets, but the materials to be leached – copper sulphate bearing soils and ores – were transported to the leaching place in order to be subject to a comparatively thorough and intensive leaching process. This method thus represented a great theoretical progress compared to the soaking method, because it showed, that not only the processes underlying vitriol water creation in the nature were understood, but also, that the application of water was largely recognized as a method providing a real alternative to conventional smelting for the processing of the same material (e.g. Chalcanthite ores) and thus marked the beginning of hydrometallurgy in a modern sense.

2) Identification of suitable materials

Just as for the copper soaking method, the search for suitable materials, stood at the very beginning of a successful application of this method. While theoretically speaking the minerals allowing a leaching out of their copper sulphate content into water may be numerous, as the *Yan shu* states, generally two types of basic materials need to be considered for the process of copper leaching: "earth ores" (*tuhou* 土鉅 or 土垢), pieces of certain chalcanthite minerals, and "earth crumbs" (*tucha* 土碴), earth from copper sulphate bearing soil layers.

A) Earth Ores

With the available information from the sources it is not possible to identify without doubts, what exactly is meant by *tuhou*. Besides the *Yan shu*, the term appears in the *Daye fu* as well:

> 得雞子之胚黃，知土鉅之所凝。[181]
>
> If one gets the embryonic yolk of the hen's egg, then one knows the place where the earth ores coagulate.

According to this description, "earth ores" must be located rather inside the solid soil than on the directly weathered surface of a deposit. The relation to a chicken egg, does not become clear in the *Daye fu*, but can be found in the *Yan shu* as well. Here the natural appearance of *tuhou* is written with the character *fan* 矾 which should almost certainly be read as a misspelling of the character *fan* 礬, alum or vitriol.

[181] DYF, see chapter X.2n of this thesis.

[…] 矽多在土石內，如雞子內黃。[182]

Vitriol pieces […] normally lay in the earth and between stones, looking like the yolks of chicken eggs.

Fortunately, a much more detailed description of a vitriol mineral resembling a chicken's egg can be found in the mineral chapters of a book treating a completely different subject: the "Revised version of the classified and consolidated pharmacopoeia of the Zhenghe reign-period [1111-1118]" (*Chongxiu Zhenghe jingshi zhenglei beiyong bencao* 重修政和經史證類備用本草) which dates from 1249 but, as the title implies, relies on material from the early 12th century.

石膽
此物出銅處有，形似曾青，兼綠相間，味極酸苦，磨鐵作銅色，此是真者。[…]真者出蒲州虞鄉縣東亭谷窟及薛集窟中，有塊如雞卵者為真。[…]今惟信州鉛山縣有之，生於銅坑中[…][183]

Stone Gall
These things appear in the places where copper is produced, having a similar shape like *zengqing*, with a mixed green colour and an extremely sour and bitter taste. If one rubs them on iron and they lend it a coppery colour, then they are real. […] The real ones are produced in Dongtinggu Cave and Xueji Cave in the Yuxiang District of Puzhou. Those who have lumps like chicken eggs are real. […] Nowadays they only exist in Yanshan District in Xinzhou, growing between the copper mines […].

Although this text does not mention egg yolks but only eggs, it is very plausible that the same mineral is described: It appears in the vicinity of copper mines, even especially of the ones in Yanshan and when rubbed onto iron it can precipitate. The "earth ore" used for the copper leaching

182 YS, chap. 1, p. 65b.

183 CXZHJSZLBYBC chapter 3, *yushi bu shangpin* 玉石部上品, *Shidan* 石膽.

process would thus be identical with "stone vitriol" (*shidan* 石膽), a term identified by Golas[184] as the mineral Chalcanthite ($CuSO_4 \cdot 5H_2O$).

Another description of *shidan* can be found in the alchemist treatise *Longhu huandan jue* from the Tang period. In this book, the mineral is described in some detail but with a focus on the creation of different medicine pills and without including its use for copper production:

> 石膽生蒲州山谷，狀似折篦頭，如瑟瑟淺碧色，燒之變白色者，是真。次宣潤等州，淋取汁煎煮而成，上者青碧色，作塊片數等級。下者如黃泥爛濕，名為泥膽，唯堪和水銀燒為粉。其宣州者，不如句容，氣力懸殊，力倍於十。其句容上者，狀如碎瓦子，堅重，鮮碧色，一半帶深綠色，甚可愛。經夏不潤，見風不損。次於蒲州，今所用結砂子者。但中色已下，並可用。又有山谷坑洞裹自然生者，色稍淺於煎成者，亦作片塊，忽遇即有，常無採處。[185]

> Stone gall grows in the valley of Puzhou[186] and has a shape like a folded toothed comb, with a cold blue-greenish colour. If after being burnt the colour changes into white, then it is real. Inferior [stone vitriol] comes from Xuan[187] and Run[188], it is obtained by leaching with water and boiling down. The good [pieces] have a blue-green colour, the shape of a lump or a slice and are divided into several levels [of quality]. The bad ones are soft and wet, like yellow mud; they can only be mixed with mercury and burnt into powder. Those from Xuanzhou are not as good as those from Jurong[189], with a great disparity in power of several dozens of times. The good ones from Jurong have a shape like a broken tile, are firm and heavy, bright blue-green coloured, with half of them

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184 Golas (1999), p. 70.

185 ZTDZ / LHHDJ chapter 3, *yushi bu shangpin* 玉石部上品, *shidan* 石膽.

186 Puzhou 蒲州, today in Shanxi.

187 Xuanzhou 宣州, today in Anhui.

188 Runzhou潤州, today in Jiangsu.

189 Jurong 句容, today in Jiangsu.

> deep-green coloured, [looking] very lovely. They nor become moist through summer, neither get damaged by wind. The inferior ones are from Puzhou, which are now used to produce grits. As long as the quality is middle to bad, all can be used. There is also some naturally growing in the valleys and pits and caves, the colour is slightly lighter than the boiled down ones and they are also shaped in lumps or slices. One can only get them by accident, cannot always find them.

This passage provides numerous explanations, which help to verify or integrate information from the other sources. Basically two different methods of obtaining *shidan* can be distinguished: Firstly appearing naturally in pieces of different shapes and secondly "by leaching out with water and boiling down." It is not mentioned clearly, what is leached out, but it is very likely, that copper sulphate bearing earth or copper sulphate bearing earth or minerals with a rather low copper sulphate content were used. The passage mentions an inferior type of *shidan*, which is "soft and wet like yellow mud", it is possible, that this description refers to what *Yan shu* and *Daye fu* call egg yolks.

Figure 11 shows contemporary depictions of several minerals related to the copper leaching method. Illustration a.) shows the *shidan* from Xinzhou, supposedly from Yanshan, itself giving an angular and crystal-like rather than a round and egg-like impression. The *zengqing* in illustration b.), however, which is said to look just like the ore pieces employed for leaching is already much rounder though still not really looking like an egg. If the image in illustration d.) is at all related to *tuhou* cannot be stated for sure, alone it is the only one appearing in a more oval shape and carrying the rare character *hou* 鍭 for "ore" in its name, implying that as "stone ore" (*shihou* 石鍭) it may be somewhat like a variation of "earth ore" (*tuhou* 土鍭).

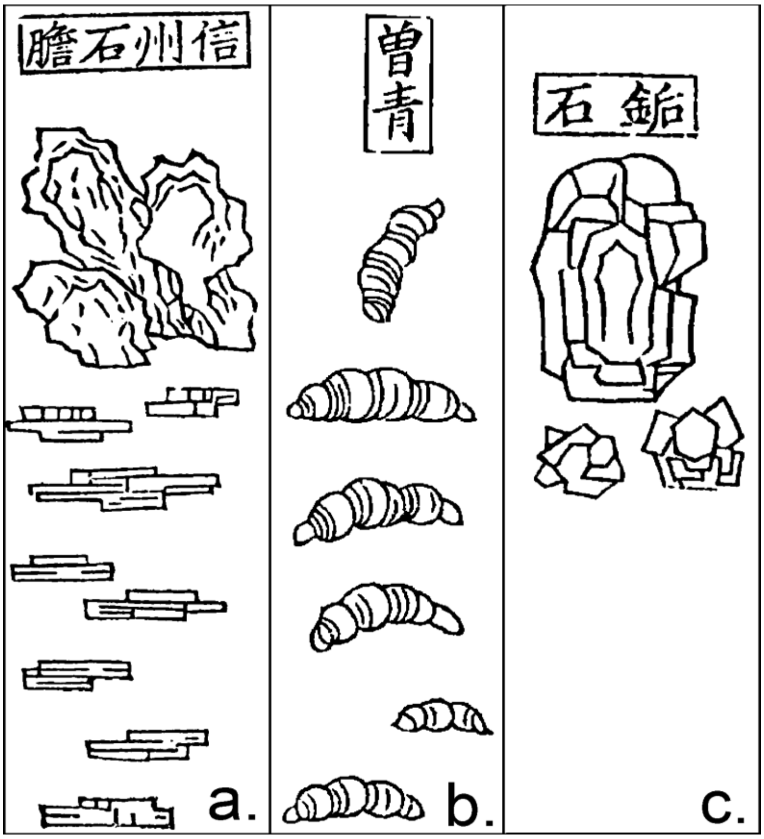

Fig. 27: Illustration in the *Chongxiu Zhenghe jingshi zhenglei beiyong bencao* depicting a.) *shidan* from Xinzhou, b.) *zengqing*, d.) *shihou*.

B) Earth Crumbs

Information on the identification of the so-called "earth crumbs" (*tucha* 土碴) is even more scarce. Besides being addressed explicitly in the *Yan shu*, the term does not appear in any other related source. The only other places, where it can be found, are the names of three copper soaking gutters in Yanshan: "Crumb basin gutter" (*chawu gou* 碴塢溝), "Upper earth crumbs gutter" (*tucha shang gou* 土碴上溝) and "Lower earth crumbs gutter" (*tucha xia gou* 土碴下溝).[190] It can be imagined, that these gutters were situated close to places, where *tucha* were obtained or stored or that even their vitriol water supply originated from rain water passing through a clearly identified and visible deposit of "earth crumbs".

If "earth crumbs" as the name may imply were in fact crumbs of copper sulphate bearing soil which also had the appearance of earth, it is likely, that it is identical with the material called "vitriol earth" (*dantu* 膽土). This expression can be found much more widely spread for example in the *Song huiyao jigao*, the *Song shi*, the *Qingbo zazhi* and other places. The *Qingbo zazhi* even states that

> 凡古坑，有水處曰膽水，無水處曰膽土。[…] 水有盡，土無窮。[191]
>
> What generally concerns old pits, it is such that the places which contain water are called [places producing] "vitriol water" and that the places not containing water are called [places producing] "vitriol earth". […] [However, the availability of] "vitriol water" is limited, [the availability of] "[vitriol] earth" is not.

Yet another name in use for this material is "earth green" (*tulü* 土綠), which appears in the *Longhu huandan jue*:

> 土綠有數般，生宣州、饒、信州、道、永等州山谷，但有銅處即生。乃是銅坑中般出壤土，經雨便生，色淺軟，爛如胡粉塊子，以手捻便成粉末者佳，硬如軟石者次。[192]
>
> "Earth green" has several types, which are produced in the valleys of Xuanzhou, Rao[zhou], Xinzhou, Dao[zhou][193] and Yongzhou[194] and

[190] YS, chap. 1, p. 64a, for more examples of gutter names, see chapter IV.2b of this thesis.

[191] QBZZ chapter 12, pp. 502-503.

[192] ZTDZ / LHHDJ chapter 3, *yushi bu shangpin* 玉石部上品, *tulü* 土綠.

[193] Daozhou 道州, today in Hunan.

> elsewhere, wherever there is copper. It grows from the earth in the copper pits after rain, with a light and gentle colour, soft like Hu-powder lump. If it can become powder after being twirled in the fingers, it is of great quality. Those as hard as a soft stone are inferior ones.

Fig. 28: Patina efflorescing on the surface of "vitriol earth" in a modern open pit copper mine near Shaoguan in Guangdong Province. The wooden beams in the middle are remains of the timbering for galleries from the Song period.
Source: Photo by the author.

The name "earth green" and the following description match well with a phenomenon which to the present day can still be observed in many copper mines. Often at the surface, where copper sulphate bearing earth

[194] Yongzhou 永州, today in Hunan.

oxidizes, patina effloresces covering everything with a light green colour. This must have been the decisive method to identify "vitriol earth" for the use in copper leaching.

3) Procurement and storage

According to most of the descriptions, pieces of "earth ore" and "earth crumbs" usually must have appeared closely besides each other with the "vitriol earth" surrounding the egg-yolk shaped *shidan* pieces. The *Yan shu* writes:

> 日逐所用，隨作分遠近，於山內尋掘取，去浮土野石，見砈即深取。若久雨，土石崩倒，亦多損壓。[195]
>
> Everyday according to the demand, [people] are distributed near and far in working teams, to search, dig and exploit in the mountains. After removing the loose surface soil and dispersed stones, they dig deeper as soon as they find vitriol.

The *Daye fu* describes the task in a very similar way:

> 剖曼衍，攻崚嶒。浮埴去，堅壤呈。[196]
>
> Dissecting is carried out on a large scale and steep and high mountains are attacked. The surface dust is removed so that the solid soil appears.

After suitable deposits of ore pieces and earth are identified and exploited, the material is first transported to special storage places:

> 輂運塞於介蹊，烞積高於脩楹。日愈久而滋力，礬既生而細碖。

---

[195] YS, chap. 1, p. 65b.

[196] DYF, see chapter X.2n of this thesis.

> Transport carriages block the small paths, and the mounds piled up are loftier than high pillars. The more days pass by the stronger its power is nourished. Then alum appears and tumbles down as small stones.

In these storage places the material was stored in big heaps and remained there for a certain amount of time in order to "nourish its power". The alum (*fan* 礬), which "tumbles down as small stones" should again refer to the formation of "earth green" on top of the heaps, which would necessarily appear if copper sulphate bearing earth is exposed to the air and weathered for a while. It is however not sure, if only the ore pieces or also the loose earth was treated that way, the *Yan shu* states:

> 每得真矾則入舍，惟合經一季，方幹燥有力，合內嘗存百余萬斤。[197]

> Whenever one obtains real vitriol (*fan* 矾) [pieces], they are put into houses. Only after one season can they become dry and enriched. Once there were more than one million *jin* in store.

From a present point of view, it is not comprehensible, what advantage would have come from storing either chalcanthite pieces or copper sulphate bearing earth for three months under a roof. Drying the material would have been of no use, since it would immediately be watered again during the leaching process. The appearance of patina on the surface would not have any notable effect either, nonetheless it is possible, that this was exactly the aim of this practice.

Although the behaviour of the material would not change over time or with the appearance of patina, especially the "vitriol earth" would have looked much more copperish and, would thus have implied a higher copper content and a greater suitability for leaching. This would be in line with the description in the *Longhu huandan jue*, which even goes as far as

197 YS, chap. 1, p. 65b.

to only consider those earth crumbs actually covered with patina as “Earth green”, but not the unchanged material below the surface.[198] If one follows this example, it is even possible, that always only the green surface of the storage heaps inside the houses were scraped off to be leached out, while the rest of it would have to wait until it would be covered in patina again. However strict the practice of only using patina-covered material for leaching may or may not have been, the colour change at the surface must have inspired the idea of plant-like growth and processual transformation so crucial for the traditional Chinese understanding of the world in general and of metallurgy in particular.[199]

4) Production Process and Facilities

Once the material was prepared and considered ready, the leaching process itself could begin.

The highest level of detail is again provided by the *Yan shu*:

> 見管舍屋五百余間，所置淋盆，每一盆用抄盆三箇，並系土石就地結成。每盆長五尺，闊二尺，深二尺五寸，竹篾一片作底。每日先裝一盆，用土碴五十擔，土垢四十擔，以水澆漓。竹用竹梘，引所淋水入溝沒鐵，日夜三換，外二盆取淡水存留，次日循環裝淋。[200]
>
> Now there are more than five hundred buildings under control. Each of the established leaching basins (*linpen* 淋盆) uses three container basins (*chaopen* 抄盆) which are all directly built on the ground with earth and

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[198] ZTDZ / LHHDJ chapter 3, *yushi bu shangpin* 玉石部上品, *tulü* 土綠.

[199] For a more detailed discussion of this as well as related questions, see chapter VIII.1 of this thesis.

[200] YS, chap. 1, pp. 65b-66a.

> stones. Each basin is five *chi* [ca. 157 cm] long, two *chi* wide [ca. 63 cm] and two *chi* five *cun* [ca. 78.5 cm] deep. The bottom is made of a board of bamboo strips. Every day one first fills one basin with fifty *dan* [ca. 33 kg] of earth crumbs (*tucha* 土碴) and forty *dan* [ca. 26 kg] of earth ore (*tuhou* 土垢) and then waters it. Bamboo pipes are used to divert the leachate into the gutters to cover the iron. Within one day and one night it is changed three times. The other two [container] basins remain to store freshwater. The next day one fills and leaches again in cycles.

The first difficulty of this source lies in its ambiguous way of expression, because in two very decisive places an object is not specified. Firstly, it is not clear if the measures and descriptions of a "basin" (*pen* 盆) which are given refer to what is before introduced under the name of "leaching basin" (*linpen* 淋盆) or to what is called "container basin" (*chaopen* 抄盆). Secondly, something is changed three times within one day and night but the text does not indicate what that might be. It would be reasonable to assume that ore and crumbs in a basin are meant, but the basins themselves or even the gutters would be an option.

What can be understood clearly is, that one "leaching basin" was somehow associated to three "container basins" and that the latter ones were directly masoned on the ground. One of these two basin types is 157 cm long, 63 cm wide and 78.5 cm deep resulting in a volume of ca. 0.78 m^3 and had a bottom which was made of bamboo strips, a stable material often used for the making of sieves or baskets very likely forming a permeable layer for water to seep through while holding back the earthen material. One basin was filled with 33 kg of copper sulphate bearing earth and 26 kg of chalcanthite pieces and water is added on top of them. The seeped through enriched water dripping out below the layer of bamboo slates flew through one or more bamboo pipes into one or more gutters filled with iron pieces. Another two basins were filled with fresh water.

The *Daye fu* mentions several parts of the process as well possible providing some supplementary information:

> 是設抄盆筠絡以度，是築甓槽竹龍以釃。[201]
>
> Container basins and bamboo skin nets are prepared to load [earth and ore] on them, tiled grooves and bamboo baskets are set up to filtrate [the water].

Fig. 29: A bamboo sieve for sorting rice made of bamboo strips (*zhumie* 竹篾) like the bottom of a "container basin" according to the *Yan shu*. Time period unknown. Source: Taiwan Digital Archives.
Link: http://catalog.digitalarchives.tw/item/00/66/7b/98.html
(visited 11/07/2013)

If the "bamboo skin nets" (*yunlao* 筠絡) of the *Daye fu* are in fact identical with the "bamboo strip boards" (*zhumie* 竹篾) of the *Yan shu*, this would be a certain indication that the basins measured and described in the latter

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[201] DYF, see chapter X.2n of this thesis.

text are actually “container basins”, though it is of course possible that the *Daye fu* refers to two separate installations in one line.

The mention of “tiled grooves” indicates that probably, other than the grooves for copper soaking described by the *Yan shu*, the grooves for copper leaching may have been constructed of bricks and tiles rather than of wooden boards. The “bamboo baskets” (*zhulong* 竹龍) could be a second set of filters established for fine-filtering of the leachate before entering the grooves and getting in touch with the water. The description continues as follows:

> 散鋇葉而中鋪，沃鉐液而下漬。勇抱甕以潺湲，馴甐瓢而滂澒。分醲淡於淄澠，別清濁於涇渭。其滲瀉之聲，步糟丘壓酒於則兵之厨；其轉引之勢，則渴烏傳漏於挈壺之氏。左挹右注，循環不竭。晝湛夕溉，薰染翕欲。幻成寒煖燥濕不移之體，疑刀圭之點鐵。[202]
>
> Then leave-shaped iron chips are spread into [the grooves], and after irrigating them with ore-bearing liquid, they are soaked through. The water flows when jars are forcefully lifted and it splashes when the gourd ladles are gently turned. Like distinguishing between the strong and the light [tasting] water in the rivers Zi and Sheng and like differentiating between the clear and muddy water in the rivers Jing and Wei. With a sound of seeping and pouring like when wine is squeezed out of a heap of fermented rice in the infantry kitchen, and with arrangements of diverting and conducting like when the Water holding Official uses the “Thirsty Raven” to feed the water clock, on the left side, water is ladled out and poured on the right side in perpetual cycles without end; seeping and watering through days and nights; getting permeated and imbued until united. Magically an object is completed, which does not change by cold, heat, dryness or humidity, as if iron were touched [and turned into gold] by a powerful essence.

This description provides a better understanding of how the watering of the earth-ore mixture waiting on a bamboo sieve within a “container

202 DYF, see chapter X.2n of this thesis.

basin" may have looked like, although it still remain too vague to be sure. With a tad of speculation the process can be imagined like this: Jars full of freshwater were filled into the two container basins installed for this purpose. After that, this water was ladled out of these basins and spread evenly over the earth-ore mixture on the bamboo sieve in the third basin. The water from the ladle seeped slowly through and surely changed its appearance by doing so, not only because it became enriched with copper sulphate, but surely also, because especially the "earth crumbs" must have contained various other elements making the water simply muddy.

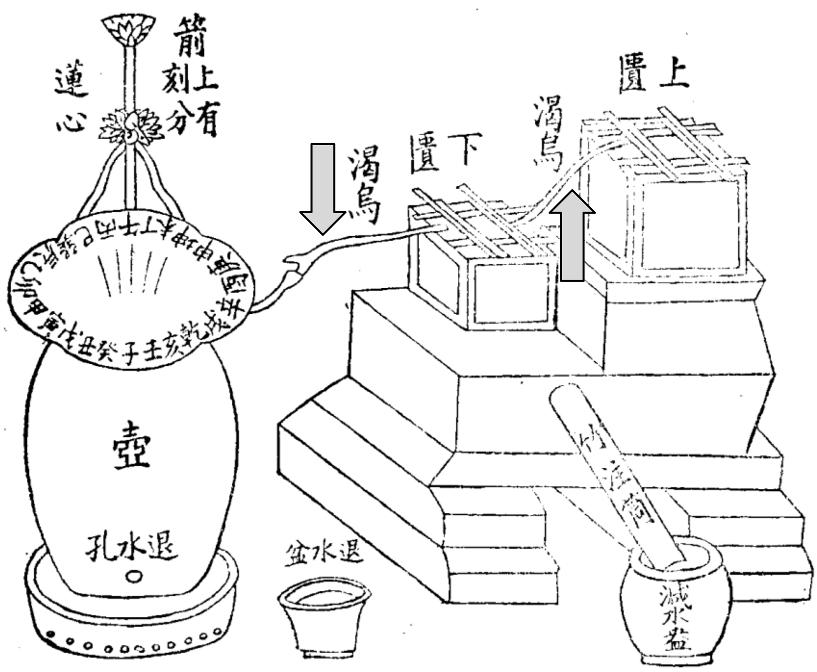

Fig 30: Chinese water clock built during the Song period "Lotus clepsydra" (*lianhua lou* 蓮花漏) of Yan Su 燕肅. The "Thirsty Ravens" (*kewu* 渴烏) are the pipes connecting the different vessels (see grey arrows). Source: LJT, chapter 3, p. 40.

The use of the term “Thirsty Raven” (*kewu* 渴烏) refers to a component of a water clock like the one built by Yan Su 燕肅 (see Fig. 30), which consisted in a copper pipe allowing the water to pass from one vessel to the next. The bamboo pipes connecting a container basin with one or more grooves may have in fact looked very similar to the ones in the illustration in Figure 14. If only one groove was used or if several grooves were in use beside or rather behind each other, comparable to the example of the water clock, is not clear.

Like the *Daye fu*, the *Yan shu* states as well, that the operation of a copper leaching facility somehow worked in certain “cycles” (*xunhuan* 循環). Apparently this cyclical operation mode was an innovation compared to another, earlier method. The *Yan shu* relates:

> 循環使用盆作。舊一十三作五桶甑淋浸一百槽，後收成不及，改作抄盆，於近处添凑一百四十槽矾。[203]
>
> [Today] basins are applied to work in circles. In former times thirteen workshops [used] five [sets of] barrels and steaming devices to leach and soak [in] one hundred grooves. Later this did not yield sufficient results, so one changed to use container basins (*chaopen* 抄盆) and added nearby one hundred and forty grooves [for] vitriol.

How barrels and steaming devices, usually vessels made of metal, clay or bamboo with a permeable bottom used for the steaming of food, may have been applied in this process is easy to imagine. A steaming device is placed on a barrel of the same size and its bottom is covered with earth and ore. After that one pours water in from above until the barrel is full and the solid material is leached out. The reasons why this mode of operation did not yielded sufficient results anymore may be several:

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[203] YS, chap. 1, p. 65b.

1. The size of barrels and steaming devices could not be increased to an unlimited extent, at least if they should still remain movable. Thus during every round of leaching, only a fairly small amount of earth and ore could be leached out.
2. Because less vitriol water was produced and this water always only became available for leaching when a barrel was emptied, it was difficult to achieve a slow but steady flow of the water like in the case of copper soaking, creating less ideal conditions for the replacement reaction.
3. By directly leaching out suitable materials on the spot, naturally much higher copper sulphate contents in the water must have been achieved than in the case of copper soaking. It can thus be imagined that by only once flowing through one groove or even through several grooves behind each other in a line, not all the available copper had precipitated. Letting this water run away would thus have been a waste, especially in later times, when earth and ore became more difficult to obtain.

A solution to these problems may in fact have been, to use much larger vessels, which had to be built on the ground, as the *Yan shu* describes it for the "container basins". Consequently, these basins could not be emptied simply by turning them over and pouring the water out any more. Instead, pipes needed to be installed to bring the vitriol water to the gutters. This directly offered a relief to the second problem: Water flowing through pipes into the gutters could run by the iron pieces much more steadily than before thus improving conditions for the replacement reaction. The last point directly leads to the understanding what could be implied by the term of "cycles".

The character *chao* 抄 in *chaopen* can simply mean "to contain" but also "to collect", it can thus be imagined, that one of the three "container" or in this particular case maybe better "collecting basins" was established behind the last groove and collected the water which had passed through them already but still contained a certain amount of copper which had not precipitated yet. In this case, the term "fresh water" (*danshui* 淡水) used by the *Yan shu* should rather be understood as "water with a low copper content" or more practically thinking "water with a light taste". From the "container basin" behind the grooves this *danshui* would be transported in barrels, as mentioned in the *Daye fu*, back to another "container basin" in front of the grooves beside the third basin, in which the bamboo sieve was installed.

Beside the "container basins", the *Yan shu* also mentions a "leaching basin" (*linpen* 淋盆) which is not included in this model. It is likely that this term does not refer to an actual basin but rather stands for the facility as a whole. This can firstly be understood from the fact that in the *Yan shu* it is stated that "Each of the established leaching basins (*linpen* 淋盆) uses (*yong* 用) three container basins (*chaopen* 抄盆). It would be at least unusual to assume that one actual basin *uses* another one, while an institution using one would make more sense. Secondly, the *Song huiyao jigao* refers to the copper leaching facilities of Yanshan as "Copper Leaching basins and grooves" (*lintong pencao* 淋銅盆槽)[204]. *Linpen* could thus be understood as an abbreviation of this expression as well.

204 SHYJG / SH chapter 34, p. 27ff.

5) Copper boiling

Besides the by far most common term for wet copper production based on solid materials, which would be "copper leaching" (*lintong* 淋銅), occasionally the term "copper boiling" (*jiantong* 煎銅) or the combination of the two terms, "copper boiling and leaching" (*jianlintong* 煎淋銅) can be traced in the sources. Both sources providing a detailed description of the process, the *Yan shu* and the *Daye Fu*, only use "copper boiling" thus leaving the question, if there is any difference in the actual meaning of these three terms to speculation.

What can be observed, however, is, that "copper boiling" seems to be a term more commonly used during the early time of wet copper production in Song China, while the use of "copper leaching" gains popularity towards the end, as can be seen from Table 5 below, which provides an overview over the appearances of the respective terms in the *Song huiyao jigao*:

Tab. 5: Appearances of the terms "leaching" (*lin* 淋), "boiling" (*jian* 煎) and "leaching and boiling" (*jianlin* 煎淋) in the context of wet copper production within the *Song huiyao jigao.*

Year	Yanshan	Censhui	Yongxing	general
1102	煎[205]			
1104				煎[206]
1115		煎，煎淋[207]		
1116		煎淋[208]		
1165	淋[209]	淋 [209]	淋 [209]	
1172		淋[210]		
1173		淋[211]		
1178		淋[212]		
1185	淋[213]			
1186	淋[214]			
1196	淋[215]	淋 [212]	淋 [212]	淋 [212]

205 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p.25.

206 SHYJG / ZG chapter 43, p. 121.

207 SHYJG / ZG chapter 43, p. 132f.

208 SHYJG / ZG chapter 43, p. 134f.

209 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 21f.

210 SHYJG / ZG chapter 43, p. 165f.

211 SHYJG / ZG chapter 43, p. 168f.

212 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 26.

213 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p.27.

214 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p.27ff.

215 SHYJG / XF chapter 2 (*jinyue san* 禁約三), p. 127.

There are certain aspects, which indicate, that in spite of the overlapping use, “copper boiling” and “copper leaching” may have been two remarkably different methods:

1. The two characters *jian* 煎 and *lin* 淋 have completely different meanings. Most importantly, *jian* definitely refers to a process including the application of heat, which is clearly not the case for the “copper leaching” method as described in the *Yan shu* and the *Daye fu*. It is also unlikely, that the character was used in this particular case with a very different meaning, because in one passage the *Song huiyao jigao* not only uses *jian*, but also includes *peng* 烹, a character carrying a very explicit meaning of “cooking” as well.[216] *Lin* in a closer sense may be understood as “watering”, “sprinkling” or “dripping”. All these terms can be easily connected to the described method but none includes any connotation of heat.
2. The *Song huiyao jigao*[217] and the *Daye fu*[218] both mention, that one Method originated from Censhui. In the case of the *Song huiyao jigao*, this is the *jiantong/jianlintong* method, in the case of the *Daye fu* the *lintong* method. At the same time, the Song *huiyao jigao* clearly mentions the application of the *jiantong* in Yanshan[219] and probably also in other places[220] at least 13 years earlier in 1102. At the same

[216] SHYJG / ZG chapter 43, p. 121.

[217] SHYJG / ZG chapter 43, p. 132f.

[218] DYF, see chapter X.2n of this thesis.

[219] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25.

[220] SHYJG / ZG chapter 43, p. 121.

time it is stated, that this method came to Yanshan from Censhui[221] It should thus be assumed, that while Censhui was probably not the first place of all to carry out any *jiantong*, *lintong* or *jianlintong* method, some important innovation of it departed from there around 1115. It is very likely, though not entirely sure that this was what later would have been called "copper leaching".

3. While the use of the "copper leaching" method later lead to enormous production results especially in Censhui and persisted for many decades successfully, the *Song huiyao jigao* states in an earlier passage, which was later included into the *Qingbo zazhi* as well, in comparison to copper soaking, that

> 膽水浸銅，工少利多，[…]；膽土煎銅，工多利少，[…]。[222]
>
> For copper soaking with vitriol water, the work is little but the profit is much, […]; for copper boiling with vitriol earth, the work is much but the profit is little, […].

This sentence from 1102 implies as well, that very likely another innovation was necessary to allow the "copper leaching" method to become as successful as it did. And in fact, to the opposite of "copper leaching", no source can be found which reports a particularly large scale or even any production numbers at all for the method of "copper boiling".

It is thus reasonable to assume, that "copper boiling" and "copper leaching" were two different methods and that the latter evolved out of the former.

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221 SHYJG / ZG chapter 43, p. 132f.

222 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p.25; QBZZ chapter 12, p. 502f.

To find out, what exactly had to be understood by the term of "copper boiling" is difficult, because no source describes this process explicitly using this name. Only a rather vague series of speculations can be attempted in order to get closer to it:

1. If "copper leaching" in fact evolved from "copper boiling", it would make sense to expect, that the character *lin* used to describe the new method addresses something, the old method did not include, thus the watering, seeping and the dripping out of the leachate at the bottom of a bamboo sieve may have been innovations.

2. Several methods using heat in order to induce the precipitation of copper on iron were applied in earlier times,[223] such as the process described by the *Longhu huandan jue*[224] in which mercury is added to a mixture of vitriol earth and water in an iron pan in order to bring forth the amalgamation of the copper. Other ways of wet copper production including cooking or boiling are described in the *Danfang jingyuan*[225] and in the *Baozang lun*[226]. The problem is, however, that none of these descriptions includes the character *jian*, which obviously later became typical for this method. Additionally, the method in the *Longhu huandan jue* would have required mercury and thus made any production of larger scale very expensive, the other two methods relied on direct precipitation on iron but used natural vitriol water, the important step of obtaining this vitriol

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[223] See chapter VII.1 of this thesis.

[224] ZTDZ / LHHDJ chap. 2, "*shidan hongyin fa* 石膽紅銀法".

[225] ZTDZ / DFJY.

[226] BCGM / BCL *jinshi* 金石, chapter 8, item *chitong* 赤銅.

water from earth or ore is omitted. It is thus highly unlikely that any of these methods exactly describes "copper boiling", nonetheless it must surely be imagined as a mixture or combination of them.

3. The *Yan shu* mentions a change from the use of "barrels and steaming devices" to the use of container basins for the execution of the process. The earlier method was abolished because it did not yield sufficient results.[227] As demonstrated above, the *Song huiyao jigao* confirms that in Yanshan a change from the "copper boiling" to the "copper leaching" method took place sometime between 1102 and 1165, thus indicating that the Method with "barrels and steaming devices" might have been the old "copper boiling" method. However, the text does not use the term *jian* for this method but *lin* as well and does not provide any further details about it.

After considering these points it still remains impossible to reconstruct, how "copper boiling" may have been practiced. Moreover, it cannot be estimated, if the term *jianlintong* was a third method combining *jiantong* and *lintong* or if it was only an early expression for "leached copper" after its establishment in Censhui which was used to show its similarity to the at this time probably more well-known "boiled copper".

[227] YS, chap. 1, p. 65b.

VI) Wet Copper Management

1) Officials

A) Supervisory Officials

Since the Yuanyou 元祐 reign-period (1086-1094), the Northern Song government began to carry out wet copper production in its southern and south-eastern regions. As has been mentioned before,[228] a specified institution was established to take charge for the task of managing this industry: the Supervisory Office for managing the copper affairs in Jiang, Huai, Jing, Zhe, Fujian and Guangnan (*Tiju cuozhi Jiang Huai Jing Zhe Fujian Guangnan Tongshisuo* 提舉措置江淮荊浙福建廣南銅事所)[229]. The first official appointed to lead this institution was You Jing 游經. At the beginning, he organised the establishment of wet copper production facilities in Censhui, Yanshan and Dexing. However, he soon left his position temporarily to go into filial mourning and his duties were taken over by other short-term acting officials (*quanguan* 權官), which lead to a loss of 50-60% in the production of wet copper[230]. In 1100, an edict said that no special offices needed to be established for wet copper

[228] see chapter III.1A of this thesis.

[229] SHYJG / ZG chapter 43, p. 121; SHYJG / SH chapter 34, p.25.

[230] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25.

management in Raozhou, Xinzhou, Tanzhou, and Shaozhou. Wet copper management should be included into the tasks of the regular minting office.[231] This certainly led to a stagnation of the wet copper production again. Fortunately, in the next year, 1101, You Jing returned to his position and brought new development impulses leading to an increase in production[232].

Once wet copper production had been established in a place, many tasks had to be fulfilled: Leaching basins and soaking gutters had to be established and maintained, facilities had to be inspected and production and supply needed to be controlled. However, no matching system had been established for this yet. Thus these works were at the beginning often taken over by acting officials sent by departments and districts. Because they only needed to take care of the tasks for a short period of time, they often lacked even most basic experience and also often did not care enough to fulfil their responsibilities well. Under these circumstances, a new system of regular officials to deal with the wet copper mines was planned to be established. In 1104, a suggestion was made to appoint Supervisory Officials (*jianguan* 監官) instead and got approved[233].

As usual, the Supervisory Officials for the mines were selected by the Ministry of Personnel according to their seniority, which was called *chaizhu* 差注 method. But this method turned out to be unsuitable for wet copper management, especially for the facilities in Shaozhou, Tanzhou and Xinzhou where the three biggest production sites were situated. If

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231 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 21.

232 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25.

233 SHYJG / ZG chapter 43, p. 121.

they should work successfully, it was inevitable that they were managed by officials with knowledge and expertise in the field as well as with a long-term planning perspective. Consequently, the Commissioner of Foundry and Coinage suggested that the supervision officials of these three big wet copper facilities as well as of other newly opened ones should be recommended by himself according to their experience and suitability and regardless their seniority.[234] This method of selecting official was called *zoupi* 奏辟 (lit.: appointing by recommendation). However, this new method never became a binding regulation but it can be seen, that later, in the Southern Song period when Li Dazheng was the Commissioner, it also happened at least twice.[235]

B) Local Government Officials

It is relatively difficult to trace, how exactly responsibilities for duties related to wet copper production were distributed on the local level. The only observation which can be made is, that during the initiating phase, the district magistrates and their administrations apparently did not play a very crucial role and things may often have been directly managed between supervisory officials and actors on the spot. Later, however, they increasingly moved into the focus and must have taken over more responsibilities. One example for this is that in 1102 it was seen as beneficial to promote the flourishing wet copper production place of Censhui into a district by itself. Of course this may also have been related to increasing population in the region, but the respective entry in the *Song*

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[234] SHYJG / ZG chapter 28, pp. 32-33.

[235] SHYJG / ZG chapter 43, p. 168, 174. See also Wang Lingling (2005), p. 299.

huiyao jigao explicitly mentions the administrative changes going along with this promotion:

> 徽宗崇寧元年閏六月二十二日，監韶州岑水銀銅場蘇堅狀，乞陞本場作縣。逐司相度到，乞撥曲江縣廉平、福建兩鄉，翁源縣太平鄉，就岑水場陞縣，仍存留監官二員，一員依舊外，一員知縣同監，並添置縣尉一員兼主簿，卻減罷本場駐(汨)[泊]一員。從之。[236]
>
> On the 22nd day in the leap-sixth month of the first year of the Chongning reign-period of emperor Huizong [1102], the supervisor of the silver-copper mine of Censhui in Shaozhou, Su Jiang, applied to raise the [administrative] level of the mine to the one of a district. He asked to let two villages from the district of Qujiang, Lianping and Fujian, as well as Taiping village from the district of Wengyuan join the Censhui mine to form a new district. [At the same time] still two supervision officials should be kept. One should be the same like before, the other one should become the district magistrate and at the same time supervise the mine. Yet another official should be added. Suggestion accepted.

For the other important wet copper producers, administrative adaptions did not involve any territorial changes. Nonetheless, in 1133 the Magistrates in the districts of Liuyang, where the Yongxing facilities were located, Yanshan and even Qujiang, the neighbouring district of Censhui were especially entitled as "supervisors of copper and lead affairs" in order to emphasize their particular responsibility.

> 張澄又言：「乞將韶州曲江、潭州(劉)[瀏]陽、信州鉛山三縣知縣依舊來饒州德興、信州弋陽知縣體例，銜位帶主管銅鉛等事，責令同監場官協力收趁歲額［…］。」從之。[237]
>
> [In 1133] Zhang Cheng suggested: "The magistrates of the three districts of Qujiang in Shaozhou, Liuyang in Tanzhou, and Yanshan in Xinzhou should be entitled with 'supervision copper and lead affairs' according

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236 SHYJG / FY chapter 7 (*zhouxian shengjiangfeizhi* 州縣陞降廢置), p. 13.

237 SHYJG / SH chapter 34 (*caiqian* 採鉛), p.34.

to the precedence of Dexing in Raozhou and Yiyang in Xinzhou. They are ordered to cooperate with the supervisory officials of the mines to collect the annual quota [of copper] together. […].” Agreed.

The same must have taken place in the Dexing district with its Xingli wet copper facilities before as well as in Yiyang, where no wet copper, but conventional copper as well as large amounts of iron for the supply of Yanshan's wet copper production were produced.

When several years later in the important production place production numbers declined and abuses became obvious, the magistrates of the respective districts were even the first ones moving into the focus of examination:

[紹興]十二年八月十九日，韓球言：「[…] 緣韶州曲江、潭州瀏 陽、信州鉛山、饒州德興四縣所管坑冶累年積弊不可槩舉，欲將前項四縣令、丞點檢得弛慢不職，課利虧欠，[…] 申奏朝廷，[…]。所有浸銅兵匠及見差那擺鋪兵級在場浸銅之人，如有違慢作過，虧欠課額，亦乞從本司將情重之人改刺重役場監。」從之。[238]

On the 19th day in the eighth month of the 12th year [of the Shaoxing reign-period] [1142], Han Qiu said: "[…] Because the mines in these four districts of Qujiang in Shaozhou, Liuyang in Tanzhou, Yanshan in Xinzhou and Dexing in Raozhou have numerous abuses, which cannot be listed here in detail. I want to examine all these magistrates with respect to their delays, their inferior work [performance], their deficiencies in taxation and report it to the court […]. Concerning all the soldiers and craftsmen involved in copper soaking, as well as all the post-station soldiers at the mines, if they are disobedient or slow or make mistakes which lead to quota deficiencies, as long as the circumstance are serious, they should be sent to places with heavier labour." Agreed.

[238] SHYJG / ZG chapter 43, p. 149f.

In another entry from 1186, the far-reaching responsibilities of the district administration especially for the courier soldiers employed in wet copper production becomes even more obvious:

> 淳熙十三年八月一日，都大提點坑冶鑄錢公事趙師羼言：「信州鉛山縣坑冶場鋪兵處，因縣道不支衣糧，畫降指揮專委任官別置倉庫支納。竊詳鉛山令、丞各係主管坑冶官，知縣以兼兵馬都監銜，趁辦銅鉛，增虧均受賞罰。其鉛山場趁銅兵級，知縣自當管轄，但未有明降指揮，所以不曾幹預。今欲將鉛山場兵級，令、丞與監場檢踏官同共統轄彈壓，措置坑冶事務。其場兵衣糧，縣丞專一拘催，及時支散。其餘有坑冶場兵處，亦乞准此。」從之。[239]
>
> On the first day in the eighth month of the 13th year [of the Chunxi reign-period], chief commissioner for foundry coinage Zhao Shiyi said: "Because the district and the circuit do not distribute clothing and food to the courier soldiers [working] at the Yanshan mine in Xinzhou, it is planned to let a specially entrusted official establish an extra storehouse to deal with receiving and expenses [for this matter]. According to my investigation, the magistrate and vice-magistrate of Yanshan are the responsible officials for mining, magistrates manage copper and lead [affairs] with the title of a 'Military Director-in-chief' and get awarded or punished according to the increase or deficiency [of the metal production]. The courier soldiers should certainly be under their control. However, there was no clear regulation for them how to conduct the soldiers, thus they have never cared about their supply in food and clothing. Now we suggest that the soldiers in Yanshan should be together controlled by district magistrate, vice-magistrate and the on-the-spot supervising official of the mine, who deals with the mining affairs. The food and clothing of the soldiers should be solely managed by the vice-magistrate (*xiancheng* 縣丞) and be distributed in time. All the other mines where there are soldiers working, should be managed in the same way. I beg this to be permitted." approved.

[239] SHYJG / ZG chapter 43, p. 175.

2) Capital, Costs and Payments

A) Labour and Funds

According to Wang Lingling[240], there were three different models of labour employment in the metal producing sector during the Song period, namely:

- **Corvee (*laoyi* 勞役)**

  including all forms of forced labour carried out by exiled prisoners, soldiers, less often by commoners as a means to replace tax payments. Corvee labourers were usually supplied with food and clothes but did not receive actual wages.

- **Recruited labour (*zhaomu* 招募)**

  often referred to as "mining households" (*kenghu* 坑戶). Workers and craftsmen involved with metal production by their own choice. Payment could be received directly for the execution of certain tasks but also for the sale of metal or semi-finished metal products to the government at a fixed price. Mining households usually had to take responsibility for their expenses like for fuel or assistant labour themselves, while basic investment capital was rather provided by the government.

- **Contracted management (*chengmai* 承買)**

  this was the most independent form of work possible in this sector. The miners managed their enterprise and invested their capital for themselves and had to pay taxes and sell a part of their

[240] Wang Lingling (2005), p. 175 f.

production to the government at a fixed price according to regulations to be negotiated in a contract between them and the government. For strictly monopolised metals like copper, this type of labour was very rare.

Generally speaking, workers in involved with the production of wet copper usually belonged to the first two types. It can furthermore be observed, that there must have been a certain shift from a majority of mining household employed during the early phase and increasing numbers of corvee workers during later time periods.

In Yanshan for example, originally mainly mining households were recruited to carry out Wet copper production. According to a report by Hong Mai 洪邁 from 1185, "in the old times, [mining] households were employed […] and could make profit, thus always more than 100000 people were employed […]."[241] However, several decades later, in 1185, Hong Mai described in the same report that now "everything gets more expensive but the government does not increase the fund for purchasing and mining households lose their profit and leave. The governmental soldiers are less than 400."[242] Here the expression "governmental soldiers" is referring to so-called "local soldiers" (*xiangbing* 廂兵) and "miscellaneous prisoners" (*zafan* 雜犯), typical categories of corvee labour. The *xiangbing* were those soldiers which, for whatever reasons, were "not matching the standard [for armed combat] or rather timid and weak"[243] and thus needed to serve as governmental corvee labourers. Besides, some groups of prisoners were often organized to become

[241] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 27.

[242] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 27.

[243] OYWZGWJ, chapter 59 (*yuanbi* 原弊).

xiangbing too. These prisoners were then often called "exile armies (*peijun* 配軍) or "exile slaves" (*peili* 配隸), whose pay was very poor.[244]

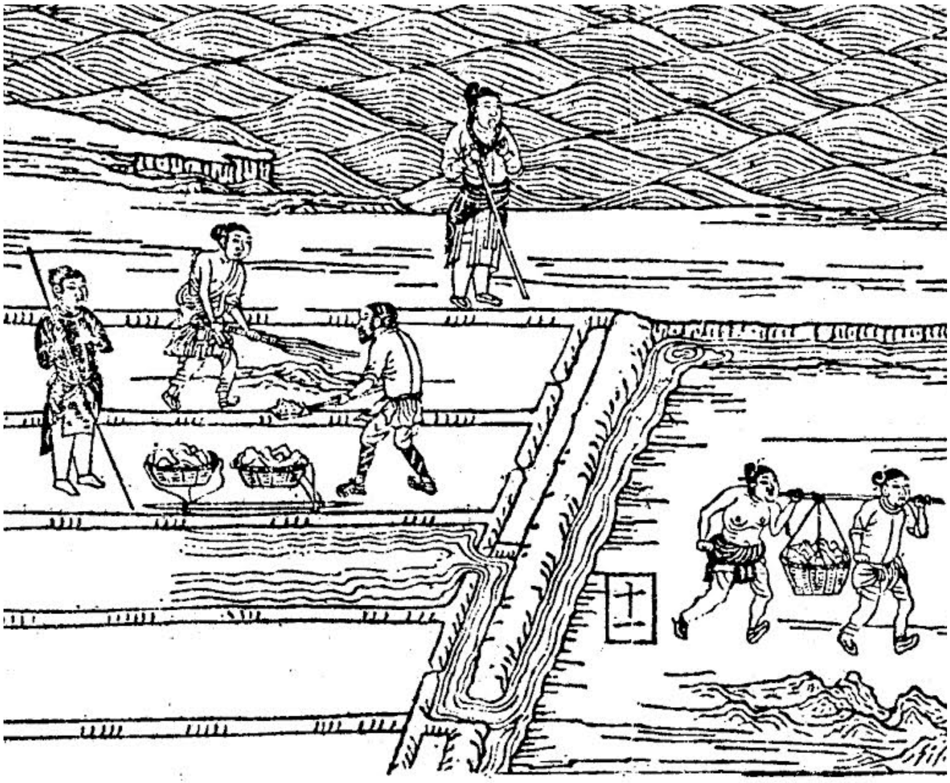

Fig. 31: An Official supervising workers working in a saltern. Illustration from the Zhenghe reign-period, the blooming time of wet copper production in China. Source: CXZHJSZLBYBC.

The change from mining households to corvee labourers must have been a gradual process and for long periods of time, both types were working side by side. This was for example the case in 1165 in Censhui.[245] In Yanshan different kinds of soldiers started to work in the wet copper facilities since 1097 and from 1101 onwards, only "local troops" (*tujun*

244 Wang Lingling (2005), p. 196.

245 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 21f.

土軍) were hired. Since 1120, courier soldiers (*baipubing* 擺舖兵) as well as soldiers and craftsmen from the Fengguo mint as well as *xiangbing* of the prefecture joined the work[246]. However, from Hong Mai's report in 1185 we know that at that time, when production had declined remarkably, also only 400 corvee soldiers were working. At the same time, apparently, the mining of ore copper (*shanzetong* 山澤銅) was always operated by mining households.

The reason for this change from the use of mining households to corvee labour in wet copper was closely related to the development of governmental the costs of and the governmental funds provided for the production of wet copper and thus to the profits possible in this industry. In 1102, the cost of producing one *jin* of wet copper by soaking stated to be 44 *wen*. The official You Jing suggested, that the fund from the government should be 50 *wen* for soaked copper and 80 *wen* leached copper, which apparently required a longer production process, harder work and more investment. In the same memorial he also postulated to strictly enforce the laws against private soaking and leaching of copper, which shows that there must have been much interest and high profits for those kinds of activities at this time. [247] It is likely, though not proven from any source, that one of the biggest benefiters from the lax execution of prohibition laws may have been the mining households themselves using this chance to gain some additional income. Conditions must, however, been rather favourable for workers entering the wet copper industry voluntarily.

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[246] YS chap. 1, p. 63b-64a.

[247] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25.

In 1165, in Censhui it can be observed that still mining households were in charge of the easier and more profitable copper soaking, while more difficult copper leaching, of which the lion's share of Censhui's production consisted, had been entirely taken over by soldiers. From this year, also a fairly detailed estimate about the use of funds by the households is provided by Li Dazheng:

> 仍將逋欠錢鐵權與倚閣，每斤實支價錢一百三十文省，除椿充經總制錢並顧工價炭，猶可得錢七十三文省。如銅色不及十分，即隨分數估剋支給。或趁辦年額之外，能有增買者，則更優支價錢四十文省。[248]
>
> First leaving advance payments and the iron [supply] aside, every *jin* of copper actually receives a fund of 130 *wen*, minus taxation and cost for charcoal and the hiring of labour, [mining households] can still keep 73 *wen*. If the copper is less than 100% pure, then the paid-out funds need to be reduced accordingly. Sometimes, if beyond the annual quota more copper could be purchased, we can give them extra funds of 40 *wen* [per *jin*].

In his memorial, Li Dazheng criticizes, that the households deliver copper of too bad quality and therefor consume too much iron, which was apparently provided by the government to them free of charge. Li argues, that if the amount of the received iron and the amount and quality of the produced copper do not stand in a reasonable relation, the mining households should be charged by the government for the iron they received before. It is Li Dazheng's intention to prove, how well-financed the households after all still were, thus the provided numbers need to rather be seen as maximum estimates than as common average numbers. The corvee labourers, however have a harder life, which needs to be improved Li writes about them:

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[248] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 21f.

應淋銅取土，皆在窮山絕頂，所役兵士皆是二廣配隸之人，衣糧經年不至。今欲依信州鉛山場兵士例，日貼支米二升半外 […][249]

> For leaching copper, [vitriol] earth needs to be obtained, which all lies at the dangerous top of the mountain. The employed soldiers are all exiled prisoners from Guangdong and Guangxi and their food and clothing supplies haven't arrived for years. Now we want to follow the example of the soldiers in the Yanshan mine of Xinzhou, that they get a subsidy of 2.5 *sheng* [~1.75 litre] of rice every day […].

Twenty years later, in Yanshan, according to Geng Yannian's calculation, the situation had probably still exacerbated, Geng writes that "by adding 40 leaching basin workshops at some even places on the top of Zhuyewu, we can obtain 20 000 *jin* of copper and will use 18 100 strings of cash" as capital.[250] If this number is correct and the mentioned capital did only include the usual capital provided to the households without any extra investment for the construction of the new building structures considered, this would imply a fund of 905 *wen* per *jin* of copper. This number would have made it surely impossible to maintain copper coinage in any even close to profitable, if at all self-sustaining manor. Table 6 shows, an overview about all the figures for funds paid for copper produced by different methods, which can be obtained from the sources:

[249] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 21f.

[250] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 27ff.

Table 6: Funds for Copper Production in different Production Places

Year	place	type of copper	capital in *wen* per jin	Source
1102	Yanshan	gall copper (*dantong* 膽銅)	50(44)	SHYJG/ SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25[251]
1102	Yanshan	boiled copper (*jiantong* 煎銅)	80	SHYJG/ SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25
?	Yanshan	leached copper (*lintong* 淋銅)	250	SHYJG/ SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 27
1125		ore copper (*kuangtong* 礦銅)	100	YSJ, chap.4, p. 8a.
1159	Xingzhou, Lizhou	ore copper (*kuangtong* 礦銅)	800	SHYJG/ SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 23
1165	Censhui	yellow copper (*huangtong* 黃銅)	220	SHYJG/ SH chapter 34 (*kengye zalu* 坑冶雜錄), pp. 21-22
1165	Censhui	leached copper (*lintong* 淋銅)	130	SHYJG/ SH chapter 34 (*kengye zalu* 坑冶雜錄), pp. 21-22.

251 44 is the actual capital, 50 is suggested by You Jing to pay more at the beginning of establishing policy.

1173	Chuzhou	pure copper (*jingtong* 淨銅)	0.25 tael silver	SHYJG/ ZG chapter 43, p. 168.
1186	Yanshan	leached copper (*lintong* 淋銅)	905	SHYJG/ SH chapter 34 (*kengye zalu* 坑冶雜錄), pp. 27-29.[252]

While the accuracy of some figures concerning the funds provided for copper production may be doubted, a general increase cannot be ignored. The reasons may have been for instance general inflation, decreasing quality of vitriol waters, exhausted deposits of vitriol earth etc. From a certain point onward, however, wet copper production must have become unattractive for voluntarily involved mining households. For Yanshan this meant that the latest after 1185, soldiers and prisoners must have constituted the vast majority of the workforce in Yanshan. Geng Yannian, however, still considered it desirable to restore the former way of employing households and gave out an announcement to invite them from all over the country. After months, still nobody had shown up[253].

Along with the development of wet copper production in Yanshan during the Southern Song period, the number of soldiers also varied from time to time. Some numbers and estimates are available. It, however, needs to be considered, that most of these figures need to be seen as minimum estimates, because it can often not be told clearly, if a source mentioning the existence of one particular type of soldiers already

[252] Calculated by the author according to the source.

[253] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 27ff.

excluded the presence of other types of soldiers or other corvee labourers.

Table 7: Soldiers working in Yanshan's wet copper facilities (1181-1237)

Year	**Number of soldiers according to quota**	**Source**
1181	1000	YS vol.7, p. 93a.
1185	< 400	SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 27.
1216-1229	1000	ZQG: chapter 5, p. 95f; see also YS vol.7, p.23a.
before 1237	500	Wang Lingling (2005a), p. 198
1237	800	Wang Lingling (2005a), p. 198

For Censhui, only once the figure of 500 soldiers is recorded as a quota in 1172,[254] a number which, however, for the usually relatively large scale of production in Censhui seems rather low.

[254] SHYJG / ZG chapter 43, p. 165f.

Considering these developments, the words used by Zhang Tao in the preface of his family's *Jintong yaolüe*, which he handed over to the Song government for the second time in 1154[255] are put somewhat into a perspective, although of course many advantages compared to conventional mining and smelting methods remain:

> 自紹聖至今六十余年，無採取之勞，無烹煉之費，而坐獲浸漬之利已不知其幾何矣。[256]
>
> It has been over sixty years since the Shaosheng [reign-period], that there are no hard work of mining, and no [expensive] costs of smelting [any more]. Instead [one can] sit down and receive the profit of steeping and soaking, no one can imagine, how much it is!

B) Types of Personnel and their Payments

While the income and thus the life conditions of the mining households directly depended on the generosity of governmental funds paid for the copper procurement for the mints, lower officials and soldiers working on the spot received a fixed income or were supplied with the needs for their livelihood. Fortunately, the *Yan shu* contains a very detailed account about the officials and labourers with very different functions working at the Yanshan facilities and their income, which is displayed in Table 8.

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[255] For more details concerning this case, see chapter VII.2 of this thesis.

[256] JDZSZP / JTYLHX(ZT), p. 41.

Table 8: Monthly payments for officials and soldiers working at the Yanshan facilities in one unknown year after 1120.[257]

Position	Copper cash in strings	Rice in *shi* 石 (1 *shi* = 70.2 l)	Textiles
CIVIL			
District magistrate (*zhixian* 知縣) (in addition to his regular income)	20		
On-spot supervisory official (*jiantaguan* 檢踏官)	17		
Mine supervisor (*jianchang* 監場)	10		
Prefectural administrative clerk[258] (*benzhou tigan* 本州提幹)	7		
Prefectural general controller (*benzhou tongpan* 本州通判) (in addition to his regular income)	5		
Vice magistrate (*xiancheng* 縣丞) (in addition to his regular income)	5		
Clerk with special knowledge (*zhuanzhi* 專知)	4		

257 YS, chap. 1, pp. 66b-67a.

258 Supposably equal with *guangan* 管幹, see Hucker (1985), item 3306.

Clerk with strong hands (*shouli* 手力)	4		
Clerk for writing and calculating (*cuansi* 攢司)	4		
Erudite for general Medicine[259] (*yibo* 醫博)	3	2	
Stationed medic (*yizhubo* 醫駐泊	3	1	
Stationed clerk[260] (*zhubo* 駐泊)	3		
Clerk for reporting copper (*shentong shoufen* 申銅手分)	3		
Storehouse clerk (*kuzi* 庫子)	2		
MILITARY			
Vice commander of the copper mine (*Tongchang fu zhihuishi* 銅場副指揮使)	1.3	2.1	17 bolts of rough silk (*juan* 絹)
Vice troop commander (*Fudutou* 副都頭)	1	2	7 bolts of rough silk (*juan* 絹)
Military group commander (*Junyuan juntou* 軍員軍頭)	1 ("additional food cash" *tianzhi shi qian* 添支食錢)	2.2	

[259] Hucker (1985), item 2989.

[260] Hucker (1985), item 1412.

Common soldier (*zhongjun* 眾軍)	0.274 (“cash for pickles” *jiangcai qian* 醬菜錢), Once a year 7.7 for winter clothes	1.65	1 bolt of undyed rough silk (*juan* 絹), 2 *zhang* [6.28 m] of other rough silk (*chou* 紬) 12 *liang* [165 g] of silk floss (*mian* 綿)
Common courier soldier (*Baipu zhongjun* 擺鋪眾軍)	0.274 (“cash for pickles” *jiangcai qian* 醬菜錢), Once a year 7.7 for winter clothes	1.35	1 bolt of undyed rough silk (*juan* 絹), 2 bolts of cloth (*bu* 布)
崇安擺鋪、豐國監、贛州鑄錢院，本州廂軍 Courier soldier from Chong’an, Fengguo industrial prefecture, Ganzhou mint and prefectural local soldiers (*Chong’an baipu, Fengguo jian, Ganzhou zhuqianyuan, benzhou xiangjun*)	0.9 (“cash for pickles” *jiangcai qian* 醬菜錢)	0.75	
New soldier (*bensi xinjun* 本司新軍)		1.65	

The poor living condition of the soldiers and prisoners was a hindering factor of wet copper production. Thus in Censhui some officials made suggestions to improve their payments and living standards and give them opportunities to become free[261].

Besides the Personnel listed in table 8, other professions were employed for the wet copper facilities. For reason which cannot be traced any more they did not receive their payments from the copper funds but from other institutions. The *Yan shu* divides these people into three categories:[262]

- **Furnace yard copper smelters (*luyuan pengtong* 爐院烹銅) (14)**
- **Ferrymen (*jiachuan* 駕船) (18)**
- **Miscellaneous workers (*zayi* 雜役) (20)**
  in charge of the following tasks: Guarding the Storehouses (*shouku* 守庫), Patroling (*shixun* 市巡), expediting lead [transports] (*cuiqian* 催鉛), expediting iron [transports] (*cuitie* 催鐵), attaching certificates (*chengyin* 承引), expediting copper [transports] (*cuitong* 催銅), giving instructions in other prefectures (*waizhou zhijiao* 外州指教、examining in other prefectures (*waizhou xiangyan* 外州相驗), escorting copper [transports] to the local commission office, (*yatong fu bensi* 押銅赴本司) [escorting copper [transports]] to other prefectures ([*yatong*]*ji zhuzhou* [押銅]及諸州, procuring clothes and food from other prefectures (*zhuzhou qing yiliang* 諸州請衣糧).

261 Wang Lingling (2005), p. 203.

262 YS, chap. 1, p. 67a.

3) Iron Supply

For the successful operation of any method of wet copper production used in Song China, iron was of crucial importance. Iron chips were placed in the gutters with vitriol water and their material slowly replaced by copper from the liquid while the iron reacted with the sulphur and was washed away. In the course of this so-called "replacement reaction", however, not as much pure copper could be obtained as iron had been consumed. The reasons for this may have been various:

- Parts of the iron were washed away before having reacted with the copper sulphate in the solution.
- Parts of the copper were washed away or otherwise lost after having reacted with the iron chips.
- Parts of the copper evaporated or combined with the slags during the smelting process.

The quantitative ratio between the produced wet copper and the iron required for this process is displayed in the sources very differently but must have generally been located between 1:1.33 and 1:5 (see Table 9).

Table 9: Quantitative ratio between copper and iron in the process of wet copper production.

Ratio	Location	Time	Source
1 : 1.33	Yanshan	1181	YS vol.7, p. 93a.
1 : 2.25.	?	?	WXTK chapter 18
1 : 4	?	1162	Wang Lingling (2005a)
1 : 5	Censhui	1224-64	Wang Shengduo (2004), p. 152.
1 : 1.5-2.5	-	modern[263]	Liang Kejun (1980)
1 : 0.88	-	modern[264]	Liang Kejun (1980)

The reason for the high differences between the different figures may be found in the different qualities of vitriol water in different places, the applied method –soaking or leaching- the use of cast iron or forged iron, fresh iron or scrap iron,[265] the flowing speed of the water, the general expertise of the operating workers and many other places. Still the first number seems extremely low and probably needs to be treated with some doubt. Generally speaking it can be assumed, that for every ton of silver produced by wet copper methods, three to four tons of iron needed to be procured and transported to the production site. Consequently, the organisation of a sufficient iron supply remained an important topic at any time and any place producing wet copper.

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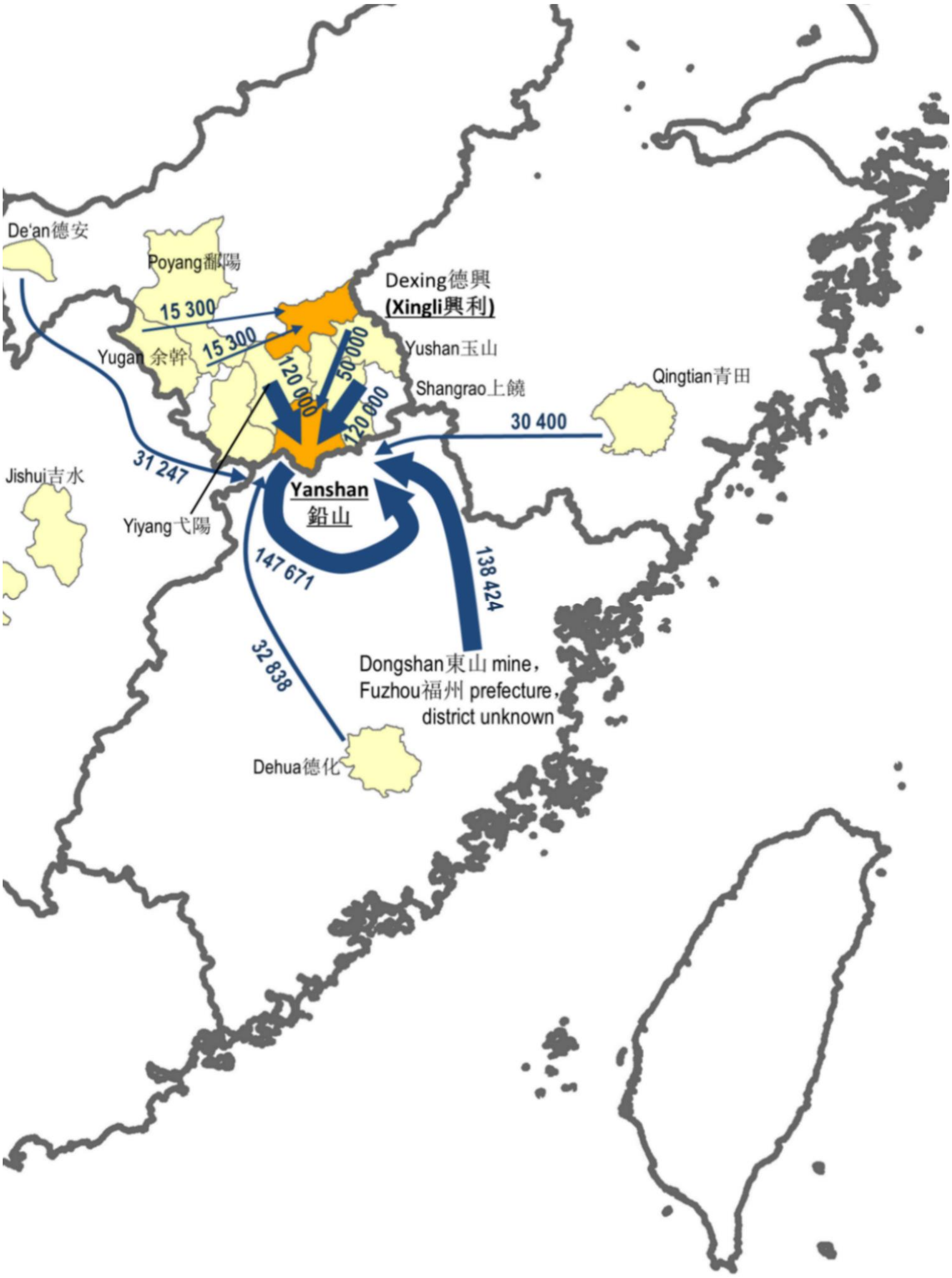
263 This number is based on practical experiments in a modern lab.

264 This number reflects the theoretical possibility according to arithmetic chemistry.

265 For a discussion on the use of different types of iron, see chapter IV.3A of this thesis.

Map 3: Routes of iron transports for the supply of wet copper precipitation facilities. Numbers refer to the original quota (*zu'e* 祖額) from the Zhenghe reign period (1111-1118) in *jin* per year.



Map Compiled with ESRI ArcGIS

based on Hartwell GIS data by Alexander Jost, 2014.

Besides on iron, copper in vitriol water can also be precipitated on tin. There is a clear reference to the use of this method in a source from the late 14th or early 15th century.[266] Only one passage from 1112 refers to the procurement of "tin and copper" (*xitie* 錫鐵) instead of iron alone in the context of wet copper production, making it unclear, if the character may have been used or copied wrongly or if the use of the tin may actually have been the creation of bronze alloys on the spot.

> 所有韶州岑水場要用錫鐵浸造膽銅，即令鑄錢司支撥銅本錢，就便收買使用。[267]
>
> For all the tin and iron which is needed for the production of gall copper by soaking, we ask the minting office to give copper funds in order to purchase more for use.

While during the early phases of wet copper production, iron could always be obtained easily, in 1132 it had become necessary to demand that all iron procured by south-eastern prefectures and military prefectures, which had access to waterways should be used for wet copper production.[268] In 1173 Li Dazheng needed to take special measures, because the iron delivered to Censhui was much too few to make use of the great amounts of natural vitriol water, which had become seasonally available in spring. He memorialised:

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[266] XHLB / STZJ vol. 90, p. 15b. See also chapter VII.5 of this thesis.

[267] SHYJG / ZG chapter 43, p. 126.

[268] SHYJG / ZG chapter 43, p. 146.

「契勘韶州岑水場趁辦浸銅、淋銅課額，全仰春水浸漬，今年一春闕鐵使用。臣至南雄州，索到收支鐵曆點對，去歲一年之間收鐵五十八萬餘斤，其南雄州只支發過二十七萬餘斤。照得般發銅鐵綱運，係本司主管、通判南雄州林次韓，今已任滿去官。見任通判曹緯自正月到任，至目下已發過鐵五十八萬餘斤，有此不同。欲望特賜處分，以為勸戒。」詔林次韓特降一官，曹緯特轉一官。[269]

"It has been found out, that the [fulfilment of] the quota for soaked copper and leached copper at the Censhui mine in Shaozhou entirely depends on steeping and soaking in the spring waters. But this spring the iron to be used [for this purpose] is lacking. I went to Nanxiongzhou and asked to check the accounts of iron receipts and payments. By doing so, I found out that in the last year more than 580 000 *jin* of iron were obtained [there] but that Nanxiongzhou only gave away 270 000 *jin*. The responsible person, the controller-general of Nanxiongzhou, Lin Cihan, who was in charge of copper iron transport, now has finished his term of office and left. The present controller-general Cao Wei has taken his post since the first month of this year and until now he has [already] conveyed 580 000 *jin* of iron. This is the difference! I suggest to punish Lin to show encourage and warning. " Edict: Lin Cihan, demote one rank; Cao Wei, promote one rank.

While in 1173, Li Dazheng could still manage the problem an obtain enough iron to let the production continue, five years later iron supply seems to have become a more general problem. This problem, however, was apparently never due to an insufficient level of iron production overall, but rather to organisational incapabilities in the transport of it. In this case it was commissioner Yao Shuyao 姚述堯 who wrote:

韶州岑水、信州鉛山等場，所產浸銅非無膽水，止緣給鐵不如其數，逐時致銅課虧少。乞下淋銅及產鐵州軍，委通判措置拘催合用鐵數發下場監，督責監官趁水淋浸。[270]

269 SHYJG / ZG chapter 43, p. 172.

270 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 26.

> It is not the case that Censhui in Shaozhou, Yanshan in Xinzhou and other mines do not have [enough] gall water to soak copper, only because the iron they are given does not suffice for the amounts [they need], which gradually resulted in the deficiency of copper taxation. I beg [the authorities to] order the prefectures which are leaching copper and producing iron to entrust a control-general (*tongpan* 通判) to take charge of the suitable amount of iron, to distribute it to the production places and to supervise the mine officials in the execution of leaching.

4) Transport

Due to the above mentioned ratio between required iron and produced copper in the process of wet copper production, iron transport was an enterprise of larger scale than copper transport at any time. Nonetheless, the transport of the finished mint metal to the respective directorates of coinage which were also often located many hundreds or thousands of kilometres away from the production places, needs to be considered as well.

Map 4 provides an interesting, though surely not entirely complete picture of the resulting transport structure based on different passages in the *Song huiyao jigao*. The up to six columns representing the annual production of wet copper (blue) and ore copper (orange) at three different time periods. The first two columns are based on numbers from the so-called "original quota" (*zu'e* 祖額) from the Zhenghe reign-period (1111-1118), for which the most detailed (intended) production numbers but no destination mints are given.[271] The second two columns show the already very much declines situation in the year 1162. For this set of data with the exception of the Yongkang 永康 mine in Wuzhou 梧州, for all production

[271] SHYJG /SH chapter 33, p.19f; see also Wang Lingling (2005), p. 50f.

places of wet copper and ore copper, destination mints are named.[272] The route between the respective mine and mint are displayed on the map as black arrows. The last two columns rely on data from the year 1166, only four years after the preceding number.[273] These data are, however only linked with the mention of the coinage office, under the administration of which each mine was arranged, but not the actual minting locations, copper from these places was conveyed to. Naturally, they do not show too much difference from the second two columns. It can be seen especially from the data of the original quota and the length of the connected transport routes, that at least at the beginning of the 12th century, when ore copper production was still flourishing, copper transports must in fact have been carried out on an even larger scale then iron transports for the purpose of wet copper production.

According to one entry in the *Song huiyao jigao*, copper and iron transport may have been carried out by the same people according to the same pattern. As it appears, usually commoners were hired according to demand to carry out the task, but sometimes also soldiers formed a so-called "copper-and-iron army" (*tongtiejun* 銅鐵軍) In the year 1163 it is reported, that before 1158 always commoners were employed for transporting and that only after this time, courier soldiers had taken over the task. It is not clear, if this information is limited to the situation of the soldiers from Nan'anjun 南安軍[274] working for the Censhui mine or if it shows a general development. If the latter is the case, it would form

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272 SHYJG /SH chapter 33, p.19f; see also Wang Lingling (2005), p. 50f.

273 SHYJG / ZG chapter 43, p. 168ff.

274 For the location of Nan'anjun on the copper transport route between Censhui and the Ganzhou mint, see Map 5.

another example for the general tendency to replace recruited commoners as in the case of the mining households by corvee labour.[275]

> 孝宗隆興元年十月十六日，戶、工部狀：「准批下提點坑冶鑄錢司申：『從來般擔銅鐵等，係是和雇人夫。紹興二十八年，承南安軍差到鋪兵六十人，前來岑水場銅鐵軍般運，多不遵依程限，搔擾鄉村。今相度，欲依舊和雇人夫般運，官司計量鐵數多少，支給錢米，委是省費，經久利便。』…」[276]
>
> On the 16th day in the 10th month of the first year of the Longxing reign-period of emperor Xiaozong [1163], the ministry of revenue and the ministry of works reported: "The Commission of Foundry and Coinage reported: 'Originally, for transporting copper, iron and the like, commoners used to be recruited. In the 28th year of the Shaoxing reign-period [1158], however, Nan'an military prefecture sent 60 courier soldiers to the Censhui mine as a 'copper-and-iron army' to do the transport. They largely disrespected route and regulations and harassed the villages. Now we are considering, if we, like before, want to rather recruit commoners for the transport again. The [responsible] governmental office [should] calculate the quantity of iron to pay for money and food, this is indeed saving, long-lasting and convenient.'[…]"

Logically, where available, transport was carried out on the water ways, as can be seen for instance from a copper ingot produced in Censhui, which was found in the Zhangshui 章水 river near Nankang 南康 in Jiangxi, had probably fallen off a transport ship.[277] This allows the assumption, that copper from Censhui used the waterway of the Zhangshui river to be transported to the coinage directorate at Ganzhou 贛州, a route on which according to the information from *Song huiyao jigao* displayed in Map 4 in

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275 see chapter VI.2A of this thesis.

276 SHYJG / ZG chapter 43, p. 156.

277 For a Photograph of this ingot, see Fig. 26.

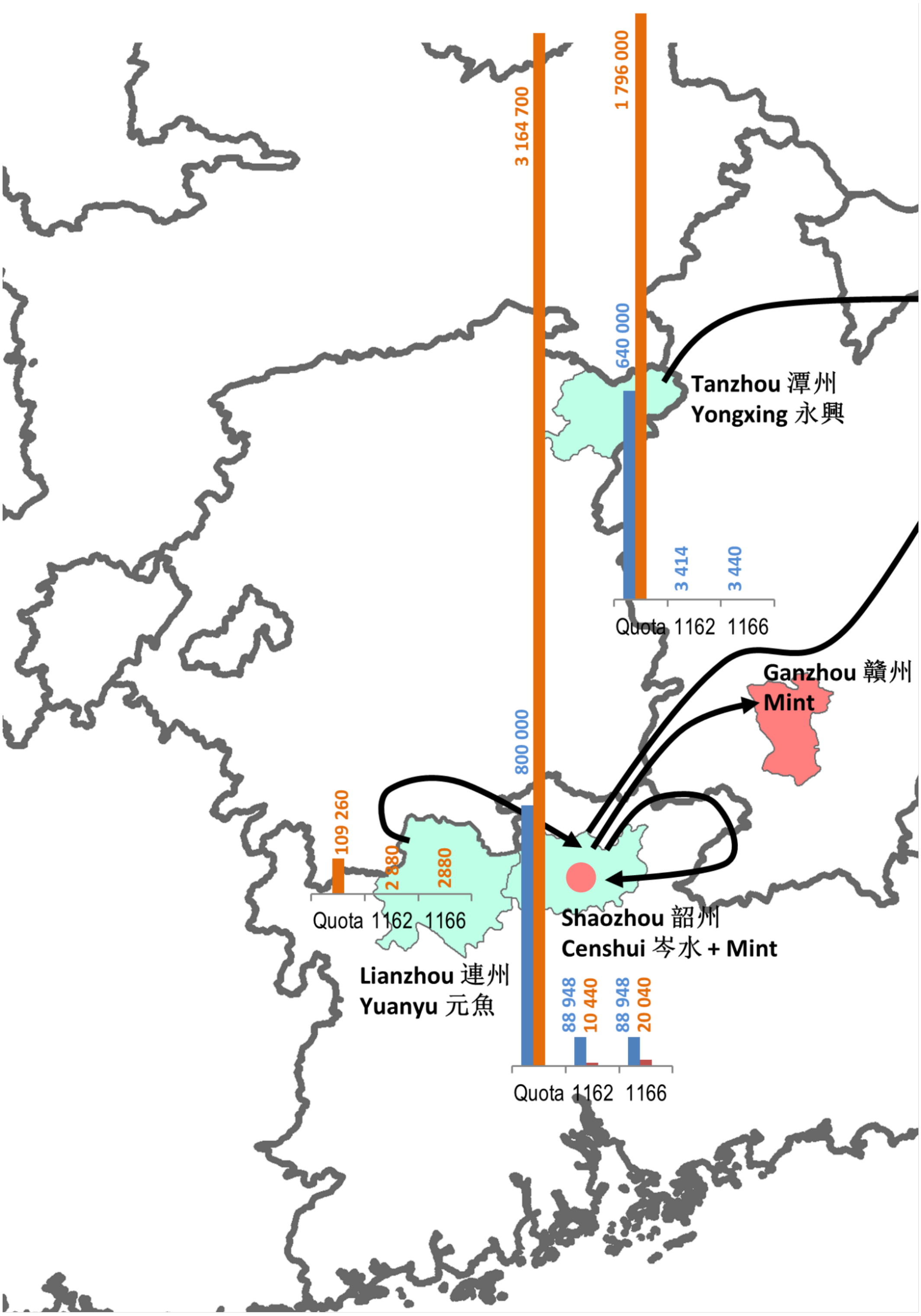
fact mint copper transports took place. This would lead to a possible transport route between Censhui and Ganzhou as reconstructed in Map 5.

The distance from Yanshan to the mint in Raozhou was considerably shorter than the one between Censhui and Ganzhou, additionally, except the short piece of way between the Yanshan mining area (today's Yongping 永平 town) and Ruikou 汭口 (probably a corrupted or just different writing for what is today the county seat of Yanshan, locally also named Hekou 河口) for the entire route, waterways, probably including the Poyang Lake could be used. The *Song huiyao jigao* records:

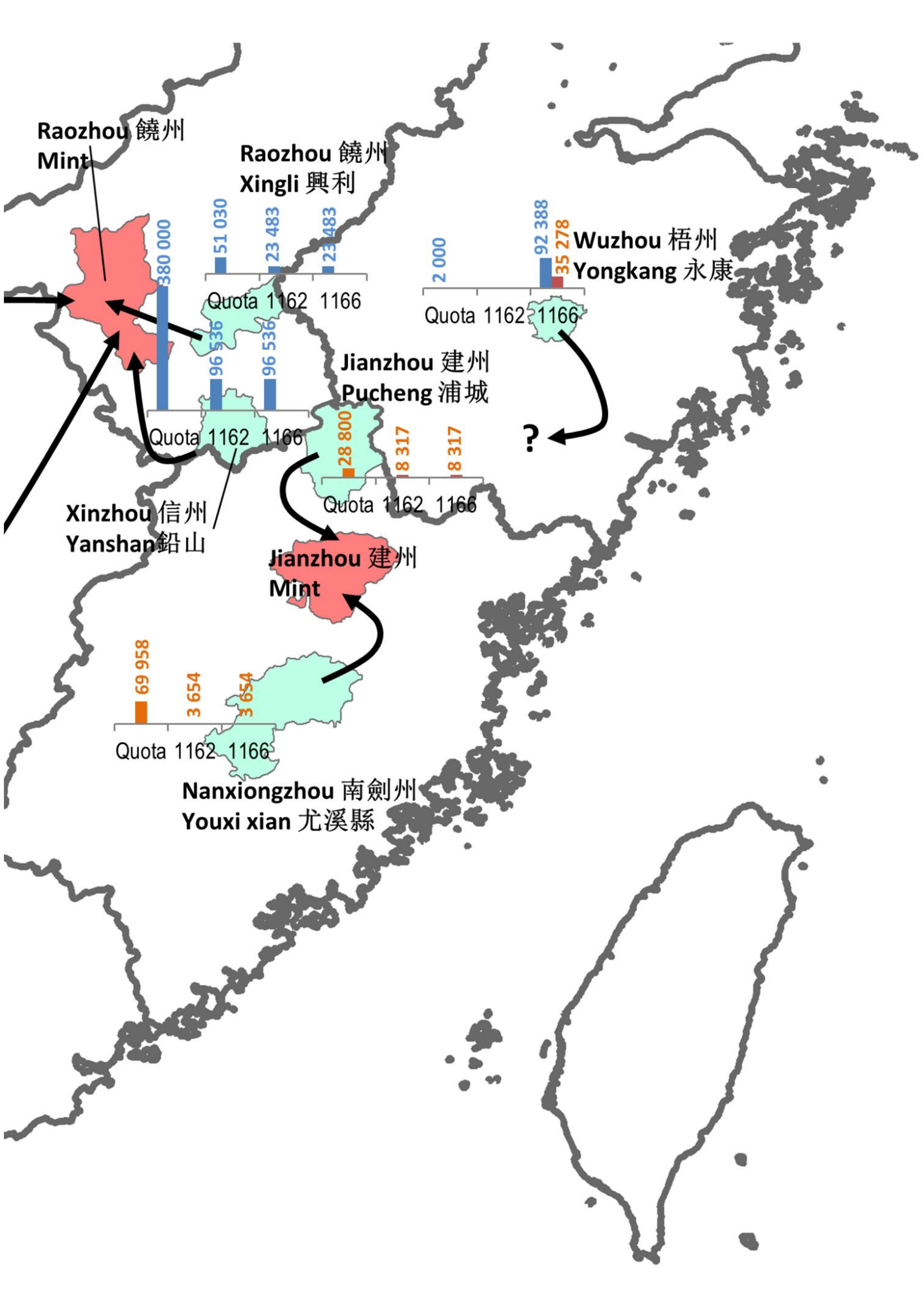
> 淳熙元年七月十日，提點坑冶鑄錢司言：「信州鉛山場所產膽水浸鐵成銅，每發二千斤為一綱，至信州汭口鎮，用船轉發應副饒州永平監鼓鑄。昨據信州通判祝大年、張竑同銜申任內催趁銅鉛及格，乞將合得酬賞分受。」從之。[278]

> On the 10th day in the 7th month of the first year of the Chunxi reign-period [1174], the Commission of Foundry and Coinage said: "At the Yanshan mine in Xinzhou copper is produced by steeping iron into gall water. Every 2000 *jin* are counted as one *gang* [transport unit]. They are sent to Ruikou town from where they are shipped out and supplied to the Yongping mint in Raozhou for casting [coins]."

[278] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25f.



Map. 4: Production of wet copper (blue) and ore copper (orange) in different mining regions of Song China in the context of the transport routes from the production places (turquois) to the mints (red).



Map compiled with ESRI ArcGIS
based on Hartwell GIS data by Alexander Jost, 2014.

Map 5: Attempt to reconstruct the transport route for mint copper between the Censhui mine and the mint in Ganzhou. Map compiled with ESRI ArcGIS based on China Historical GIS 4 time series data by Alexander Jost, 2014.

The *Daye fu* sings the praise of the copper transport system, enlarging its reach deep into those regions which usually only cast iron coins such as Sichuan (Shu 蜀):

> 若乃丱課登，綱程促。鐵往銅來，錫至鉛續。川浮舳艫之銜尾，陸走車擔之縱屬。出嶺嶠，下荊蜀。絕彭蠡洞庭而星馳，泝重淮大江而電逐，四趍圜府，如輻有轂。[279]
>
> Thereafter mining taxes are levied and convoy transports are expedited. Iron and copper are coming and going, and tin and lead are arriving and departing. On the rivers, bows and sterns [of ships] are floating in close succession and on overland [routes], carts and carriers are lined up like a rope. Out they go of the Lingqiao Mountains, descending to Jing and Shu, across the Poyang and the Dongting Lakes speeding like falling stars and upstream the Huai and Yangtze Rivers chasing like lightings. From all four directions they are heading for the heavenly treasury like spokes to the hub.

[279] DYF, see chapter X.2o of this thesis.

VII) Rise and Fall of Wet Copper

1) Origins of Knowledge

While knowledge about copper sulphates and their characteristics were already fairly widespread in most parts of the ancient world,[280] notes on observations about their transformation into copper or their reaction with iron can only be found in China for much more than a millennium. The first mention of such a reaction presumably dates from the 2nd century BC and is contained in the "Ten thousand infallible arts of the Prince of Huainan" (*Huainan wanbi shu* 淮南萬畢術). There it is stated that:

> 白青得鐵，即化為銅。[281]
>
> When baiqing is in contact with iron, the iron immediately turns into copper.[282]

According to Lung, *baiqing* 白青 is "a weathered, greenish mineral, most probably brochantite (basic copper sulphate, $Cu_4(OH)_6SO_4$)"[283] The next appearance of a related reaction is up to 400 years younger but probably based on older materials, instead of *baiqing* the "Classical pharmacopoeia

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280 For more Details see chapter IX.1A of this thesis.

281 HNWBS 0694, p. 7.

282 Translation by Lung Tshun-ni, see Lung (1986), p. 114.

283 Lung (1986), p. 126.

of the Heavenly Husbandman" (*Shennong bencao jing* 神農本草經) refers to a material called *shidan* 石膽, probably Chalcanthite ($CuSO_4 \cdot 5H_2O$):[284]

> 石膽[…]能化鐵為銅[合]成金銀。一名畢時。[285]
>
> *Shidan* […] can turn iron into copper, [and be mixed] into gold and silver. It is also called *Bishi*.[286]

The next description is goes much more into detail. It is included in the "Thirty-six methods of making mineral solutions" (*Sanshiliu shuifa* 三十六水法), an alchemist book from a Daoist background, which was most likely compiled during the Eastern Han period (25-220 AD) as well. This text uses yet another material, namely *fanshi shui* 礬石水, an aqueous solution of a certain "alum stone", which should be a copper bearing iron sulphate mineral for the reaction:

> 礬石水
> 取礬石一斤，無膽而馬齒者，納青竹筒中，薄削筒表，以硝石四兩，覆薦上下，深固其口，納華池中，三十日成水。以華池和塗鐵，鐵即如銅，取白治鐵精，內中成水。[287]
>
> Alum Stone Water
> Take one jin [ca. 220g[288]] of alum stone in the shape of a horse-tooth and without "gall"; place it in a green-bamboo tube which has a shaved thin wall. Use four liang [ca. 55g] of saltpetre to cover the top and bottom of the tube and seal the openings tightly. Immerse it in a vinegar pool for 30 days, then an aqueous solution is formed. After mixing with vinegar and smearing the solution on iron, the iron will show a reddish colour

[284] Lung (1986), p. 126.

[285] SNBCJ, p. 137.

[286] Translation by Lung Tshun-ni, see Lung (1986), p. 114.

[287] ZTDZ / SSLSF.

[288] All information on weights and measures, see Qiu Guangming et al. (2001).

resembling copper. Iron dust dropped into the solution will be dissolved.[289]

"Gall" (*dan* 膽) is a character which appears often in the context of alums or vitriols in traditional Chinese descriptions, for instance *danshui* 膽水, *danfan* 膽礬, *dantong* 膽銅. It can be assumed that it indicates to the bitter taste of these substances. What it refers to in this context is not clear. While this passage as a whole doubtlessly refers to copper precipitation on iron and is thus the earliest text which does so mentioning the use of an aqueous solution and thus a true "wet copper method", the role of saltpetre and vinegar is left to speculation. It has been argued, that certain microbes contained in the vinegar might have supported the reaction in a similar way as nowadays microbes are employed in Biohydrometallurgy.[290] Interestingly, the Japanese scholar Mori Tateyuki 森立之 (1807-1885) in his comments on the above cited *Shennong bencao jing* mentions, that in 19th century Japan a certain plum sauce water (*baiko shosui* 梅子浆水) was used in a similar reaction.[291]

A later comment to the *Shennong bencao jing* includes vinegar into the process as well. It uses a solid, supposedly copper sulphate bearing mineral called "chicken dirt alum":

礬石
其黄黑者名雞屎礬，不入藥，唯堪鍍作，以合熟銅。投苦酒中，塗鐵皆作銅色。外雖銅色，内質不變。[292]

[289] Translation based on translation by Lung Tshun-ni but slightly changed by the author, see Lung (1986), p. 114f.

[290] Guo Zhengyi (1983), p. 60, for more information on Biohydrometallurgy see Rossi, G. (1990). Biohydrometallurgy, Hamburg: McGraw-Hill.

[291] BCJKZ chapter 1, item *kongqing* 空青.

[292] Tao Hongjing 陶弘景 (452-536): Bencao jing jizhu 本草經集注 (Collected commentaries on the classicial pharmacopoeia of the Heavenly Husbandman), non-

Alum stones:
One dark yellow sort [of alum stones] is called "chicken-dirt alum" (*jishi fan* 雞屎礬). It is not used in pharmacy but only suitable for coatings [which make things look] the same with pure copper. It is thrown into vinegar, then smeared onto iron and turns its colour entirely into the one of copper. Although the outside colour becomes coppery, the material inside remains unchanged.

Copper sulphate minerals were used by Daoists for various purposes, thus during the Tang period (618-907) a lengthy alchemist treatise on the already mentioned mineral *shidan* can be found. After describing ways to find and to identify it, a short poem is inserted, which bears vague reference to its use for the creation of copper as well:

白珠碧水平鐺中，文武微微聲漸雄。
一伏三時成半死，再烹經宿變成銅。
將軍此朝須舞劍，青腰小兒莫相厭。
白霜理石常煞人，黃礬石膽從來艷。
鐵堝土釜各文武，一須五時連夜煮。
開匣見玉須焚香，仙人遇之名長久。[293]

White pearls and blue-green water in the flat-bottomed wok,
Cook it with mild and intense fire, gradually the sound becomes louder.

After one *fu* (?) and three double-hours it is half dead.
Cook for another night and it becomes copper.

The general needs to perform a sword-dance this morning.
[Thus] the pretty woman and the little child, don't come to disturb.

Lead acetate[294] and calcium sulphate[295] are usually white.
Yellow alum and stone alum are always bright-coloured.

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existent, reconstituted by Shang Zhijun 尚志鈞 and Shang Yuansheng 尚元勝, Beijing: Renmin weisheng chubanshe, 1994, p. 138.

[293] ZTDZ / LHHDJ, chap. 2.

[294] BCGM chapter *jinshi* 金石 1, item *qianshuang* 铅霜.

In an Iron crucible and an earthen *fu*-pot each use mild and intense fire,
to cook it overnight for five double-hours.

When opening the pot and seeing the jade, burn incense,
When the sages meet it, they will name it "perpetuity".

Around the same time another Daoist source already locates the technique of wet copper production in the same regional context in which it was going to develop to an industrial scale later. The nature of the described observation, however, remains clearly accidental and spontaneous rather than deliberate and systematic:

今信州鉛山縣有苦泉，流以為澗。挹其水熬之，則成膽礬，即成銅。煮膽礬鐵釜，久久亦化為銅矣。[296]

Now in Yanshan county in Xinzhou there is a bitter spring, which flows down as a mountain stream. [If one] ladles out its water and boils it, it becomes vitriol, soon it becomes copper. The iron fu pot, in which the vitriol has been boiled, also changes into copper.

Wang Shengduo, doubts the original character of this passage and rather suggests, that only the compilers of a later version of this text may have inserted the place names under the influence of Shen Gua's 沈括 "Brush talks from Dream Brook" (*Mengxi bitan* 夢溪筆談), while earlier, not extent versions might have confined themselves to the mention of the phenomenon alone.[297] The identical passage however, appears in the *Mengxi bitan* as well, so that it should generally be assumed that this much newer work, which was compiled in 1088, may have borrowed this content from the *Danfang jingyuan*.[298] At any rate, its inclusion in the

295 BCGM chapter *jinshi* 金石 3, item *lishi* 理石.

296 ZTDZ / DFJY.

297 Wang Shengduo (1996), p. 18.

298 Guo Zhengyi (1981), p. 62, 67f.

largely popular *mengxi bitan* must have made the phenomenon much more well-known than its former appearances in alchemist literature.[299]

During the time of the Five Dynasties (907-979) in the "Treatise on the treasure storehouse" (*Baozang lun* 寶藏論) a passage which was later cited by Li Shizhen 李時珍 in his "Compendium of materia medica" (*Bencao gangmu* 本草綱目) mentions the phenomenon briefly. To the opposite of all its predecessors it does not relate to the precipitated copper as a coating or a copperish colour only, but as an actual material, which can be obtained by smelting and which has characteristics of its own:

> 鐵銅
> 以苦膽水浸至生赤煤，熬煉成，而黑堅。[300]

> Iron copper
> [Iron] is soaked in bitter gall water until red powder grows. After boiling and melting, [iron copper is] obtained, which is blackish and hard.

This passage is remarkable insofar as it describes a process, which clearly exceeds the pure recognition of the surface of an iron object which is covered by a copper or copper powder after a certain treatment. Nonetheless it cannot be stated for sure, if the resulting "iron copper" (*tietong* 鐵銅) is actually scraped down copper powder which is roasted (*ao* 熬) in order to reduce its sulphur content and then smelted (*lian* 煉) for refining or if after the appearance of copper powder on the surface of the iron the vitriol water is slowly boiled down (*ao* 熬) and after that the solid-powdery mixture of iron, copper powder and dry copper sulphate is

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299 MXBT chapter 25 (*zazhi er* 雜志二), p. 276f.

300 BCGM / BCL *jinshi* 金石 (metals and stones), chapter 8, item "red copper" (*chitong* 赤銅).

smelted (*lian* 煉) in order to form an alloy. The remark that the result was blackish and hard rather indicates the latter or at least points to extremely high iron content.

The last existing written record before the known invention and establishment of large scale wet copper production already falls into the period of the early Song Dynasty. It consists in nothing but a mere downsized annotation added to a contemporary citation from the already mentioned *Huainan wanbi shu*. This annotation is of a certain interest, because it is a part of the "Imperial overview from the *Taiping* [*xingguo* reign period]" (*Taiping yulan* 太平御覽) and thus originates from the immediate surroundings of the court. Beyond this, it provides no new information and no higher level of detail, indicating, that while in fact basic knowledge about the phenomenon of wet copper production had reached the capital, no further use of it had been made yet (annotation in braces)

> 白青
> 《淮南萬畢術》曰：白青，得鐵即化為銅。{取礬石、白青，分等，鍊冶，合鐵，即成銅矣。}[301]
>
> *Baiqing*[302]
> The *Huainan wanbi shu* relates: When *baiqing* is in contact with iron, the iron immediately turns into copper. {One takes alum stone, baiqing and divides them into levels. After smelting them and adding iron in, this becomes copper.}

About 50 years later, a very interesting case appears, which is related to a certain Xu Shen 許申, who suggested to lower the cost of minting copper cash by applying a new method he called "using a drug to change iron [so

[301] TPYL chapter 988 (*yaobu wu*) 藥部五, *bai qing* 白青.

[302] Most probably chalcanthite.

it can] join copper" (*yi yao hua tie yu tong* 以藥化鐵與銅). This method is later mentioned by Wei Su 危素 during the Yuan period and treated it as the earliest though rather unsuccessful attempt of applying a wet copper production process on a large scale.[303] Interestingly, in the name for the method, he replaced the character *yu* 與, which means "to join" by *cheng* 成, which means "to transmute".

> 當宋之盛時，有三司度支判官許申，能以藥化鐵**成**銅，久之，工人厭苦之，而事遂寢。[304]
>
> In the prosperous period of the Sung dynasty, the government treasurer Xu Shen knew how use a drug to **transmute** iron into copper. After a long period, the operation was ended owing to the workers being unable to sustain the hardship of the job.[305]

The "Extended continuation to the Comprehensive Mirror to Aid in Government" (*Xu Zizhi tongjian changbian* 續資治通鑒長編) was finished in 1183 and thus at a time much closer to the related event. It contains a fairly detailed description of the case and is very likely also the source, from which Wei Su had obtained his knowledge. The relevant passage reads as follows:

> 申在三司，景祐元年十月丁巳朔，申始以工中權度判。乃建議以藥化鐵與銅雜鑄，輕重如銅錢法，而銅居三分，鐵居六分，皆有奇贏，亦得錢千，費省而利厚。因入內都知閻文應以納說，朝廷從之，即詔申用其法鑄於京師。然大率鑄錢雜鉛錫則其液流速而易成，雜以鐵則流澁而多不就，工人苦之。初命申鑄萬緡，逾月才得萬錢。申性詭譎，自度言無效，乃求為江東轉運使，欲用其法鑄於江州。朝廷又從之，詔申就江州鑄百萬緡，無漏

303 For more information on Wei Su, see chapter VII.5 of this thesis.

304 WTPJ / JTYLX (WS) chapter 10, p. 11b-12b.

305 Translation partly by Lung Tshun-ni (1986), p. 120, partly by the author.

其法。中外知其非是，而執政主之，以為可行，然卒無成功。……明年十二月甲申，申自江東徙湖南。[306]

[Xu] Shen was a member of the State Finance Commission (*sansi* 三司), since the first year of Jingyou reign-period [1034] as a Director within the Ministry of Work he had begun to be in charge of casting. He suggested using a drug (*yao* 藥) to change iron [so it can] join copper, with the same weight like the method of copper cash casting, but with the proportion of thirty per cent copper and sixty per cent iron, both parts have [certain] fractional figures. By this method also thousands of coins could be obtained, but the cost would be low and the profit high. Because the eunuch office manager (*runei duzhi* 入內都知) Yan Wenying persuaded [the emperor] to take this suggestion, the imperial court accepted it and immediately ordered [Xu] Shen to apply this method for casting in the capital. However, normally when casting with lead and tin, the liquid of melt ran fast and the result was easily achieved; but when mixed with iron, [the liquid] ran stagnant and often could not succeed. Thus the workers had their difficulties with it. At the beginning [Xu] Shen was ordered to cast ten thousand strings of cash, but after more than one month he could only get ten thousand coins [i.e., ten strings]. Being a devious person, [Xu] Shen considered that explaining this [to the emperor] could not help him anything, so he asked to be [transferred to the position of the] Fiscal Commissioner of Jiang[nan] Eastern Circuit, where he could apply the method of casting in Jiangzhou. The imperial court agreed to this again and ordered him to cast one million strings of coins in Jiangzhou and not to leak out the method. Everybody in the central and local governments knew that this was something wrong, but certain responsible officials asserted it and thought that it could work. In the end, however, it did not succeed. In the twelfth month of the next year [1035], Shen [was] moved to Hunan from Jiang[nan] East.

It is unfortunate that the "drug", which Xu intended to use, was not defined any closer and it must thus be considered doubtful if the method described had in fact any relation to wet copper production or not. Basically, two different ways of understanding are possible:

306 XZZTJCB chapter 116, *Jingyou er nian* (the second year of Jingyou Reign-period [1035]).

1. Xu Shen used a special substance, which increased, or was said to increase the fluidity of copper-iron alloys, which usually have a uncastably thick viscosity. By doing so he wanted to lower the material cost in the mint because iron was much cheaper than copper.
2. Xu Shen used vitriol water to produce wet copper, but the reaction was only understood as "changing iron (*hua tie* 化鐵) but not explicitly as "turning it into copper (*cheng tong* 成銅) as Wei Su did. The result may still have been difficult to handle, because the precipitate either retained too many impurities or the iron was only transformed on the surface, while it still remained iron inside.

The case remains a subject of discussion: Wang Shengduo argues, that the process may have referred to wet copper methods, because the *Songshi quanwen* 宋史全文, a source from the Shaosheng reign-period (1094-1098) brought the use of wet copper in the mint into a relation with similar quantities (60+x to 30+x) as Xu Shen did.[307] Wang Lingling discards this argument, by pointing out, that in many cases alloy relations in the mint were fixed in such a way.[308] Very convincing is furthermore Wang Lingling's suggestion, that although probably during Xu Shen's lifetime, hardly anyone knew about the possibility of producing wet copper, when Li Tao 李燾 published his work in 1183, wet copper production was already carried out for close to a century in China and had a prominent position among the state's monopoly industries. It is thus hard to believe that Li would not have known about its existence; and if he knew about it,

[307] Wang Shengduo (1996), p. 19.

[308] Wang Lingling (2005a), p. 94.

it seems again unlikely, that he would just have let the description end the way it did without any further explanation.

2) Beginning of Large-scale Production

The scattered pieces of information, which are contained in the sources about actual events relevant for the history of wet copper production are hardly enough to create a coherent narrative. Nonetheless it is possible to locate certain developments in time and space and illustrate several points of focus. In this chapter one focus is set on the establishment of wet copper production, which is attributed to the Zhang family from Dexing in Jiangxi. After discussing the background and value of their innovation, bits and pieces are picked up to trace the further development of wet copper production until its final decline towards the end of the Song period.

As has been shown in chapter II/4 of this thesis, knowledge about solid and aqueous vitriols and their ability to somehow react with iron had been existing in China for centuries if not millennia. However, several steps were still missing to develop a curious natural phenomenon into an economically efficient production method for one of the most important commodities in imperial China. These steps were:

1. It had to be recognised and widely accepted that the material change on the surface of the iron actually *was* copper and not a mere colour change of iron.
2. A method had to be developed to separate the iron and its copper coating efficiently while avoiding to obtain a material with too high iron content.

3. A suitable smelting process for this material had to be determined
4. A general mode of operation had to be found, which allowed an execution of the reaction on a large scale in order to be economically attractive.

It is always difficult to firmly prove the non-existence of knowledge at a certain period of time by purely arguing with the non-existence of sources. For the earliest establishment of wet copper production, however, various types of sources together not only bear witness by providing "earliest mention" records, but offer an actual narrative for this innovation. This narrative is staged in the Xingli 興利 mining area around the present-day city of Dexing 德興 in Jiangxi and centred around a certain Zhang Qian 張潛 and numerous later generations of his family.

Zhang Qian was a resident of the village of Wuyuancun 吳園村 near Xingli and father of Zhang Pan 磐, the author of the no longer extant "Outline of copper soaking" (*Jintong yaolüe* 浸銅要略), in which all the important knowledge on the topic available to him must have been assembled. The book was handed over to the government in 1094 by Zhang Qian's other son Zhang Jia 張甲. Jia wrote a preface for it, which, other than the book itself, survived as a part of the Family book of the Zhang family from Jiadao 甲道 compiled in the year 1765. In this preface, he provides much information about his father and the invention of "copper soaking" (*jintong* 浸銅). His description states clearly, that Zhang Qian never postulated to be the first inventor or discoverer of the replacement reaction itself. Being a studied man, he seems to have obtained his primary information on the method from one or more books himself. Zhang Jia writes:

> 故《神農本草》載：石膽能化鐵為銅。妙極神通有至於此，信哉！百工之事皆聖人作，然其說具存，其所以化之之術，綿歷數千百年，未有能知之者。往往爐修鼎煉之事，皆為虛語。惟家公藏書該廣，甚至古今異記無不編集，遂得其法，秘密不傳，歲月因循，未獲一試。[309]
>
> The old *Shennong bencao* has recorded that stone alum (*shidan* 石膽) can turn iron into copper. Magical and miraculous, just like this! It were then all saints who did these hundreds of works. Although the texts still exist, the [actual] methods to carry out such works are not known through thousand or hundreds of years. The talks about alchemy and practice are often unfounded. However, my father has collected books extensively, even covering all kinds of ancient and present unusual records. Thus he got to know the method and kept it as a secret.

Several decades later, the book must have been lost in the course of the war with the Jurchen and the events leading to the breakdown of the Northern Song Dynasty. In 1154, Zhang Tao 張燾, grandson of Zhang Pan and thus great-grandson of Zhang Qian reedited the book and compiled a preface of his own, in which he gave a similar account:

> 曾祖博覽群書，下至方技小說，無不研究，遂得變鐵為銅之妙，以授祖父及叔祖，使訪諸銅竇有膽水處試之。[310]
>
> My great-grandfather read and investigated all kinds of books including prescriptions and techniques as well as miscellaneous writings, thus got to know the magic of turning iron into copper, then taught it to grandfather and granduncle (i.e. Zhang Jia), and let them search copper holes which contained water and try it out.

It is not clear, for how long Zhang Qian had known the method and, if he relied on other sources of information, too, or if he obtained his detail knowledge by conducting his own experiments. However, after keeping it secret at the beginning, political circumstances must have become

309 JDZSZP/JTYLX(ZJ), p. 40.

310 JDZSZP /JTYLHX (ZT), p. 41.

increasingly favourable in 1094, so that the family decided to bring its knowledge to the public:

> 曰："此利國術也。事成可以助朝廷之用度，所補豈淺哉！"祖父、叔祖稟命而行。久之，始得其地，於信州鉛山試之，果有殊效。曾祖喜曰："是殆天相，夫豈偶然。"乃謂[祖]父曰："爾方從事科舉。"謂叔祖曰："爾有幹略，可言於朝，為國宣力。"遂命叔祖詣闕，具以其說獻之。又命祖父撰成此書，以傳永遠，以備官司詢訪。朝廷即下其法於鉛山，及饒之德興[興]利、韶之涔水等處。行之一歲，收銅無慮數百萬計。一時嘆異，驚所未睹。論功推賞，授叔祖三班差使，減三年磨勘，差監鉛山銅場。[311]
>
> [Zhang Qian] said: "This is a technique which benefits the nation. If carried out successfully, it can help the finances of the imperial court. How much it can aide!" Grandfather (i.e. Zhang Pan) and granduncle (i.e. Zhang Jia) received his order and executed it. It took a long time until they found a place. They tried it in Yanshan in Xinzhou, and indeed the effect was great. Great-grandfather (i.e. Zhang Qian) said full of joy: "This is almost a blessing from heaven. How can it be just accidental?" Then he told grandfather: "You have just started your career with imperial examinations." And told granduncle: "You have talent and strategy for work, you should report it to the imperial court and offer your help for the country." Thus he ordered granduncle to go to the imperial court and report his method. He also ordered grandfather to compile this book perpetual existence and consultation by the government. The imperial court immediately gave the order to carry the method out in Yanshan and Xingli in Dexing in Rao[zhou] as well as Censhui in Shao[zhou] and in other places. After being carried out for a year, the copper obtained was numbered with millions. At that time people were astonished of this fact which they had never seen and praised it. [The emperor] dispensed rewards according to merit, appointed him as "*Sanban chaishi*" 三班差使 [attendant of the Three Ranks], reduced three years official evaluation and dispatched him to supervise the copper mines at Yanshan.

Zhang Pan must have been the intellectually more capable of Zhang Qian's sons, given that he was intrusted to write the *Jintong yaolüe* and, that he had successfully passed the imperial examinations. Zhang Jia, on

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311 JDZSZP /JTYLHX (ZT), p. 41.

the contrary, had not achieved any career yet, thus he was selected to be the contributor of the book to the court – a well-calculated action, which within short brought him the rank of a "Sanban chaishi" and made him head of the important copper mines at Yanshan. It is remarkable, that, although the Zhang family was situated close to the Xingli mines, Zhang Tao states clearly, that first operations were tried out at Yanshan, not there. In 1094, however, before large-scale operations started, Zhang Jia described his experiences to the government with the following, very literary words:

> 甲游泳太平，竊慕古人之高風， 建功立名傳之後世，內顧蹇淺，力莫能就。堂有垂白之親，不敢遠適，登山臨水，特以舒懷。因瞰銅竇，忽見清[青]流，挹而嘗之，氣味俱厚。輒閱所秘，聊試其可，浸凝未幾，大成厥效。驚喜嘆頌，竊謂聖明述作，德侔覆載。[…] 饒之德興、信之鉛山，悉有可浸，就其多者，已條敘本末，上獻公府。兩邑之人，爭趨從事。夙夕自念，仰惟天休，顯相大業，民庶之家，豈得專享。復表登聞，請歸官造。[312]

> I, Jia, enjoy peace and security and admire the high spirit of the old, who brought forth merits and achieved a fame passing on over later generations, but consider myself only lame and shallow with no strength to get close [to them]. With white-haired parents at home I could not travel far. I could only climb mountains and gaze at the water to unburden my heart. By accident I saw from above (or: "far away") a copper hole and a blue-green[313] stream. I ladled out the water and tried it, smell and taste were both strong. I immediately checked the secret method and tried if it could work. Soaking and congealing did not take long and the result was enormous. Happily Surprised, I sighed and praised that the virtue of the sages' works is as big as heaven and earth.

[312] JDZSZP /JTYLHX (ZT), p. 41.

[313] The original source says "clear" (*qing* 清) instead of "blue-green" (*qing* 青), supposably the three-dotted water radical was added at the left wrongly during a later copying, since *blue-green* water would be a main indicator for some copper sulphates solved in water.

> […] There are places where soaking can be carried out in Dexing in Rao[zhou] and Yanshan in Xin[zhou]. I already listed them and wrote them down from the beginning to the end and handed it over to the government. The people in these two towns were all in a hurry to join in. Day and night I had thought by myself: How can such heaven-blessed luck and great prosperity be exclusively enjoyed by a commoner's family? Thus I again reported to the government and asked for official arrangements.

The Zhang family seems to have stayed in close relation to the business of copper soaking and remained the guardian of the *Jintong yaolüe*, which, before its traces were lost, was for the last time handed over to the Yuan government in 1352 by another member of a much later generation in Zhang Pan's family branch, Zhang Li 張理.[314]

Copper soaking must have paid well, as from Zhang Jia's report onward, many members of the Zhang family appear to have held important official positions and even more attended the official examinations successfully.[315] Of three family members, grave steles with detailed inscriptions have survived, which are not only repeating the information given by the prefaces about their involvement into wet copper production, but also about the wealthy lifestyle resulting from their occupation. This includes various examples of philanthropic deeds like for instance dike-building or the support of actions against banditry in the region. The members of the Zhang family owned many great estates and gave splendid receptions for large numbers of guests.[316]

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[314] WTPJ / JTYLX (WS) chapter 10, p. 11b-12b. See also chapter V.2c of this thesis.

[315] For more details about the history of the Zhang family from Jiadao see e.g. Chen Dingrong (1991), Sun Yigang (2003), Sun Chengping (2003, 2006).

[316] Chen Dingrong (1991).

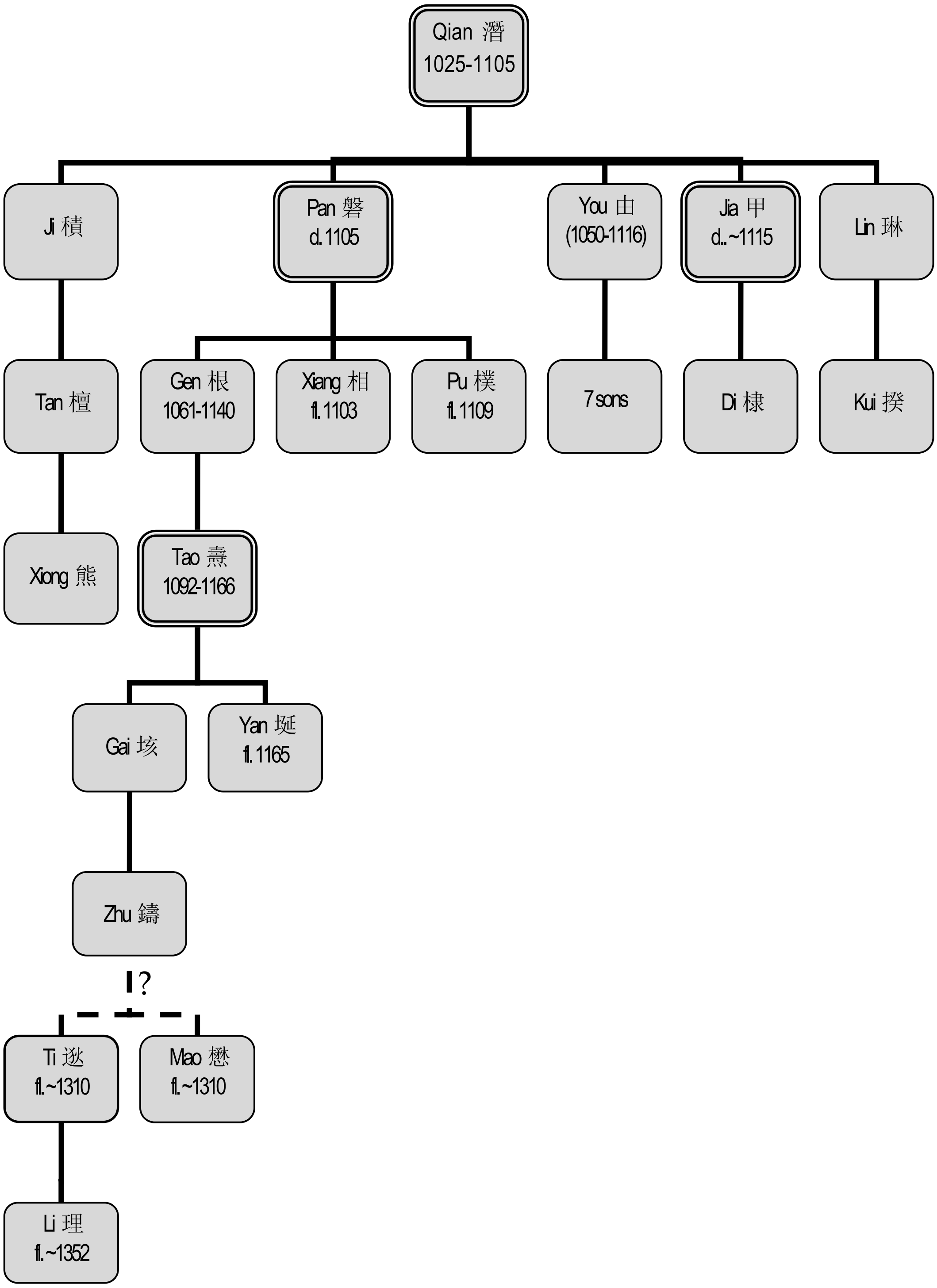

Chart 3: Partial family tree of the Zhang 張 family from Jiadao, the family members mentioned in the text are marked by a double frame. Source: Chen Dingrong (1991).

Fig. 32: Rubbing of the upper part of Zhang Tao's grave stele, Dexing City Museum. Source Chen Dingrong (1991), p.92.

3) Important Production Places

After copper soaking facilities had first been established[317] in the mining areas of Dexing 德興 and Yanshan 鉛山, which both belonged to the prefecture of Raozhou 饒州 in today's Jiangxi Province, the technology spread fast over other suitable places inside the country. Soon also methods involving the leaching of vitriol earth were applied. The following one and a half centuries saw phases of rise and decline of wet copper production in a multitude of places involving countless surrounding factors creating altogether a very complex structure of a very developed history in close connection with the core interests of Song politics. Unfortunately, sources on this time are relatively scarce and no records which would allow us to retrace the entire history of this industry as a coherent narrative exist. The only available source containing at least something about the event history of wet copper production in Song China is the *Song huiyao jigao* 宋會要輯稿, a large document collection providing scattered pieces of information on various aspects of the topic. While on most production places close to nothing appears, at least for the mining regions of Yanshan and Censhui a number of records can be found, which will be rather listed than integrated into a complete storyline on the following pages.

A) Yanshan

Yanshan was one of those places, where the beginning of wet copper production was related to the experiments of the Zhang Family and still

[317] see chapter III.2 of this thesis.

took place before the end of the 11th century.[318] The first entry in the *Song huiyao jigao*, mentioning it dates from the year 1102. According to this entry, the responsibility for the mine must soon have been taken over by the official You Jing 遊經, who at the time of this entry had already returned from his period of filial mourning, which according to the Confucian practices should have been not significantly less than three years[319].

> [崇寧]元年，戶部言：「遊經申：自興置信州鉛山場膽銅已來，收及八十九萬八千八十九斤八兩，每斤用本錢四十四文省，若製撲膽銅鑄錢，每一貫省六百餘文，其利厚重。自丁憂解職之後，皆權官時暫監管，致今膽銅十失五六。今再除職事以來，自今年正月至九月二十日終，已收膽銅一十七萬二千一百二十三斤八兩。然亦合行措置.古坑有水處為膽水，無水處為膽土。膽水浸銅，工少利多，其水有限；膽土煎銅，工多利少，其土無窮。措置之初，宜增本減息，庶使後來可繼。膽水浸銅，斤以錢五十為本，膽土煎銅，斤以錢八十為本，比之礦銅，其利已厚。若從上次寬立本錢，所貴銅課增羨。偷盜膽銅與私壞膽水，或坑戶私煎膽銅，乞依紹聖五年敕文約束。」從之。[320]
>
> In the first year [of the Chongning reign-period] [1102], the board of revenue said: "You Jing applied that since the wet copper [facilities] at the Yanshan mine in Xinzhou were established, 898089.5 *jin* of wet copper were obtained, every *jin* costs a capital of 44 *wen*. If we use this wet copper to cast coins, for every string we can save more than 600 *wen*. The profit is huge. Since I went into filial mourning, affairs were temporarily controlled by acting officials, which lead to a decrease of 50-60% in the production of wet copper. Now I have been appointed to this task again. Since the first month of this year until the 20th day of the ninth month, we have already obtained 172123.5 *jin* of wet copper. However, we still need to manage well. Between the old pits, if there is water, then it is gall water, if there is no water, then there is gall earth. If one uses gall water to conduct copper soaking, then the work is little

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[318] see chapter III.2 of this thesis.

[319] Kutcher (2006), p. 1f.

[320] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p.25.

> and the profit is great; but the water is limited. If one uses gall earth to boil copper, then the work is much and the profit is little; but the earth is unlimited. At the beginning of managing [a wet copper facility], we should increase the capital and care less about the profit. Only by doing so, the production can be sustainable. If one uses gall water to soak copper, every *jin* needs a capital of 50 *wen*. If one uses gall earth to cook copper, every *jin* needs a capital of 80 *wen*, for which compared to ore copper, the profit is already better. Thus we should relax the limit of giving out capital in order to expect a higher copper production. Stealing wet copper, privately ruining gall water, as well as private boiling of gall copper, all this should be restricted according to the regulations given in 1098."Approved.

This entry provides rich evidence of the quite prosperous early years of Yanshan's wet copper production, but it also shows that apparently from the very beginning of wet copper production in China, the state had to struggle to defend its monopoly. With the little capital available to carry out copper soaking, this was of course even more a problem than it would have been for the smelting of copper ores. That vitriol earth was considered to be unlimited shows that the production of any earth-based boiling or leaching method must still have remained in a quite primitive stage.[321]

The next entry is 13 years younger and deals with the introduction of a new method of obtaining copper through leaching, which must have been discovered in Censhui just recently and which could double Yanshan's overall wet copper output. Apparently, during this early phase of copper leaching, there must still have existed some confusion concerning the

[321] The production numbers and costs mentioned in this passage will be discussed in chapter VII.1A of this thesis.

terms "boiling" (*jian* 煎) and "leaching" (*lin* 淋).[322] The enthusiasm about wet copper production, however seemed to be unclouded still at that time.

> 政和五年四月十六日，江淮荊浙福建廣南路提點坑冶鑄錢虔州司奏：「昨饒州岑水場措置刱興煎銅之法，本場收到煎淋銅二十七萬一十斤。舊來每年亡收膽銅三十餘萬，因本司措置刱添煎淋碴銅等，遂收及六十餘萬斤。其煎淋銅功利不小，永遠歲歲得銅鑄錢，補助上供。」[323]
>
> On the 16th day of the 4th month [of the Zhenghe reign-period], the Qianzhou office for mining, smelting and minting in the circuits of Jianghuai, Jingzhe, Fujian and Guangnan reported: "recently the Censhui mine in Raozhou [correct: in Shaozhou] invented a method of boiling copper. Our mine has obtained 270 010 *jin* of boiling and leaching copper. Before, for every year we could only obtain some 300 0000 *jin* of gall copper; now, because our office has adopted the method of boiling and leaching copper crumbs and other things, now we obtain more than 600 0000 *jin*. The contribution of boiling and leaching is really big. Hopefully we can get copper and cast cash every year forever!"

In the following year as we can see from the development of the quota,[324] wet copper production in Yanshan did not continue to develop on such a high level as before after that, also no significant entries further illustrating the history of the facilities at Yanshan can be found for decades.

In 1181 Li Dazheng 李大正 was appointed commissioner of foundry and coinage and still in the same year took action to improve the situation in Yanshan, which had already declined a lot compared to its former prosperity. When after strong rain, a very promising new vitriol water rivulet had been discovered at a place called Suoshanmen 鎖山門, he initiated the building of a dam to protect it from being mixed with other

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322 For more details, see chapter V.4 of this thesis.

323 SHYJG / ZG chapter 43, p. 132-133.

324 see chapter VII.4 of this thesis.

water and by doing so made the construction of new wet copper production facilities possible. From this event, many actions involved into the construction and establishment of wet copper production facilities can be observed very well.

The "Gall spring inscription by the District Defender of Song [period] Ma Ziyan" (*Song wei Ma Ziyan danquan ming* 宋尉馬子嚴膽泉銘), which has been recorded in the *Yan shu* as well as in the Gazetteer of Yanshan from the Qianlong period provides this vivid example:

> 其水勢{世}不多有，出鉛山者倍他處{視他處多有也}。其味酸，其色青，其稱膽泉，蓋賁泉也。[…]子嚴{莊甫}嘗攝是官。乃五月庚辰，大雨霖以震。役夫馳告鎖山之門雨暴水溢，力施無所也。趣命駕視之，則水落而涸也。安撫使狀其事以聞上，命李公往視焉。六月甲子，役夫復馳告：東鎖山數十步，睹澗流可異焉。澗水常濁，至是中流有揚其清者，使酌焉，果膽泉，[…].[325]

> This [vitriol] water in the world is not much. That in Yanshan is twice as much as in other places. Its taste is sour, its colour is blue-green and its name is "gall spring" (*danquan* 膽泉), [because] it [comes from a] gushing spring. […] Ziyan [the author of this inscription] was once the acting official [here]. It was on the day of *gengchen* in the fifth month [June 18, 1181], when heavy rain and thunder came. The workers ran to report that the rain was too much, that there was a flood at Suoshanmen, and nothing could be done. I drove there urgently to examine it, then water level dropped and it dried up. […] the military commissioner described the situation and reported to the emperor, who ordered Li [Dazheng] to go there and examine it. On the day of *jiazi* in the sixth month [August 1, 1181], workers again ran to report that several ten steps to the east of Suoshan, they had seen something strange with the mountain stream. Usually it had been muddy, but in this place some clear water was flowing out clear in the middle of its current. He told

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325 YS, chap. 7，pp. 93a-94b & YSXZ / QL, chap. 12, pp. 69b-70b. Because both texts in this place contain various obvious mistakes and are also not identical, they need to be consulted together. The characers with a grey background are only contained in the *Yan shu*, the characters in curly braces are only contained in the Qianlong Gazetteer.

people to ladle the water out and it turned out indeed to be "gall spring", […].

In order to make the facilities usable, the precious vitriol water needed to first be separated from common water, which was achieved by building a dam:

未㲹{幾}，公寔{實}來相脈地形。曰：澗，盈涸不常者也，大水時就灌矣，盍圖所以經久者。於是登山之陽，顧膽上流曰：吾得之矣。即西去泉數百步，導{道小}澗水自北山之汙，而注之江，聚石為隄[堤]，以翼蔽泉。若是其無患矣。[…]百夫代興，居無何，澗通而隄亦就。隄徑千{十}尺而高倍之，其長又十倍，澗深而{兩}尋，而廣四[四上有一撇]之，其長又百倍。[…] 凡為工一萬有奇。[…] 以九月丙戌始事，十一月己酉畢工。[326]

Not long later, Sir [Li Dazheng] came in person to check the topography and said: "A mountain stream is something unstable, sometimes full sometimes dry, when there is much water, it pours. How to plan then something that will last?" He climbed to the south face of the mountain, watched the stream how it covered the gall [water] and said: "I have found it!" Then several hundred steps to the west of the spring, he diverted the mountain stream through the low-laying area at the north of the mountain and let it flow into the river. He gathered stones to make a dike in order to protect the spring. Like this, there would not be any trouble any more. […] Hundred men started working, not long and the stream was through and the dike was built up. The dike had a diameter of 10 *chi* [c. 3.14 m] and a height twice as much [c. 6.28m] and length ten times as much [c. 31.4 m]. The depth of the mountain steam was 1 *xun* [c. 2.51m] with its width being four times as much [c. 10.04] and its length being one hundred times [c. 251m] as much. […] there were more than 10 000 workers employed; […] The work began on the *bingxu* day in the 9th month [October 22, 1181] and finished on the *yiyou* day of the 11th month [December 20, 1181].

Four years later, in 1185 the important scholar-official Hong Mai 洪邁 from Raozhou describes how he has heard from the district magistrate of

326 YS, chap. 7，pp. 93a-94b & YSXZ / QL, chap. 12, pp. 69b-70b.

Yongkang 永康, a certain Yu 余, that Yanshan's wet copper production compared to "the old times" has declined to less than one tenth.

> [淳熙]十二年七月十二日，[…] 洪邁言：[…] 因咨訪耆老，皆云昔係是招集坑戶就貌平官山鑿坑，取垢淋銅，官中為置爐烹煉，每一斤銅支錢二百五十。彼時百物俱賤，坑戶所得有贏，故常募集十餘萬人晝夜採鑿，得銅鉛數千萬觔，置四監鼓鑄，一歲得錢百餘萬貫。數十年以來，百物翔貴，官不增價收買，坑戶失利，散而之他，而官中兵匠不及四百人，止得銅八九萬斤。人力多寡相去幾二百倍，宜乎所得如是之遼絕也!其說欲乞專委提點官就鉛山縣置局，採訪舊例興複坑戶，每一斤銅增錢收買，[…] 詳觀此說，殊為有理。乞詳酌專委耿延年使知其策，議其可否。[327]

> On the twelfth day in the seventh month of the twelfth year [of the Chunxi reign-period] [1185], Hong Mai, […] said: "[…] If one asks the old people, they all say that in former times, mining households were employed to gravel pits at Maoping mountain to obtain [earth] ore for copper leaching. The government set up furnaces for smelting and for every *jin* of copper funds of 250 *wen* were received. At that time, everything was cheap. Mining households could make profit, thus always more than 100 000 people were employed to exploit the mines day and night. Several dozen millions of *jin* of copper and lead were obtained. Four mints were established to cast more than one million strings of cash annually. Several decades later, everything gets more expensive but the government does not increase the funds for purchasing and the mining households lose their profits and leave. The governmental soldiers are less than 400 people, producing only 80 000 – 90 000 *jin* of copper. The strength of the workforce compared [to that time] has decreased almost 200 times, no wonder that the output has become so few! He said he suggested to establish an office in Yanshan district and to follow the old example of employing mining households and increasing the fund for every *jin* of copper […]. After making some detailed thoughts, I regard this idea as reasonable. I entrust Geng Yannian to become acquainted with his [Yu's] plan as especially responsible person and to find out if it can be carried out or not.

It is not clear, to what extent this suggestion was taken, but apparently great new plans were made by Geng Yannian only one year later in

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[327] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p.27.

Yanshan implying, that new capital had become available and could be invested. Now it was Geng Yannian himself, who introduced the plan:

> [淳熙]十三年正月二十八日，江淮等路提點坑冶鑄錢耿延年言：「[…] 其山特鉛山場一小山爾，況其地穿鑿極甚，積土成山，循環複用，歲月寖久，兼地勢峻倒，不可容眾。[…] 臣今來又檢踏出葉塢山巔秤平數處，更可增四十槽，其合用添招兵匠 […] 於竹葉塢山巔見有地稍平數處可以更增置淋銅盆槽四十所，得銅二萬斤，會計合用本錢一萬八千一百餘貫，可添鑄折二錢八千貫文外，別無相度。[328]
>
> On the 28th day in the first month of the 13th year [of the Chunxi reign-period] [1186], commissioner of foundry and coinage Geng Yannian said: "This [Maoping] mountain is just a singular hill at the Yanshan mine and it has been exploited to the extreme. Its earth piled up again forms a mountain [as well] and has been cyclically utilized over a long period. Besides, its shape is too steep to allow many people to work at same time. […] Now I have come to investigate and found several flat places at the top of the [Zhu]yewu [plateau] where 40 grooves can be added. We should employ more soldiers and craftsmen and build up houses. [I have suggested] to add 40 copper leaching basin workshops at some even places at the top of Zhuyewu. Like this, we can obtain 20 000 *jin* [of copper]; we will use a capital of some 18 100 strings of cash and can cast another 8000 strings of 'value two' coins."

From the later descriptions in the *Yan shu*[329], which are discussed in detail in other places of this thesis, especially in chapter IV, it can be seen, that Geng Yannian's plan was in fact executed and must have led to a remarkable increase at least of Yanshan's output of leached copper making the Zhuyewu 竹葉塢 plateau after Maoping mountain 貌平山 and later Suoshanmen 鎖山門 the third important location for wet copper production within the Yanshan mining region.

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[328] SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 27f.

[329] YS, chap. 1, p. 65b.

B) Censhui

The Censhui 岑水 mine, which was located at the same spot with today's Dabaoshan 大寶山 open pit copper mine near Shaoguan 韶關 in northern Guangdong was Song China's biggest producer of wet copper during most of its time in operation. Accordingly, it is also the place for which most entries can be found in the *Song huiyao jigao*. The first one goes back to the year 1047 and mentions nothing else than the fact that a mine was established in Censhui.[330] Eight years later in 1055, it is already reported, that this mine, which at that time is of course only producing copper by smelting ores, had already developed into a large one.

It is not clear, when exactly Censhui began to employ wet copper methods, a report from the year 1102 leads to the assumption, that it continued to develop successfully, but does not mention anything about leaching or soaking:

> 徽宗崇寧元年閏六月二十二日，監韶州岑水銀銅場蘇堅狀，乞陞本場作縣。逐司相度到，乞撥曲江縣廉平、福建兩鄉，翁源縣太平鄉，就岑水場陞縣，仍存留監官二員，一員依舊外，一員知縣同監，並添置縣尉一員兼主簿，卻減罷本場駐(汨)[泊]一員。從之。[331]

> On the 22nd day in the leap-sixth month of the first year of the Chongning reign-period of emperor Huizong [1102], the supervisor of the silver-copper mine of Censhui in Shaozhou, Su Jiang, applied to raise the [administrative] level of the mine to the one of a district. He asked to let two villages from the district of Qujiang, Lianping and Fujian, as well as Taiping village from the district of Wengyuan join the Censhui mine to form a new district. [At the same time] still two supervision officials should be kept. One should be the same like before, the other one should become the district magistrate and at the same time

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330 SHYJG / SH chapter 33 (*gelu kengye zhichang wusuo* 各路坑冶置場務所), p. 3.

331 SHYJG / FY chapter 7 (*zhouxian shengjiangfeizhi* 州縣陞降廢置), p. 13.

supervise the mine. Yet another official should be added. Suggestion accepted.

While Yanshan already reported in 1115, that a new method of "boiling and leaching (*jianlin* 煎淋) copper had been invented in Censhui[332] and taken over, the official beginning of such kinds of operations are only recorded for Censhui in the following year. Only in 1116, it was reported: "The Censhui mine in Shaozhou is now ready to boil and leach gall copper."[333] Production numbers show, that copper leaching in Censhui was extremely successful and within short must have made the place into China's biggest wet copper producer at its time.[334] Entries in the *Song huiyao jigao*, however, cannot be traced from the following years. Only in 1160 the change of the responsible official is briefly recorded.[335]

The next entry providing a higher level of detail is from the year 1165 and already shows a significant decline for the production of copper through ore smelting at Censhui. The production of Wet copper, however, did not seem to give reason for worries yet:

> 又言：「近點檢韶州岑水場黃銅遞年課額，雖號二三萬斤，而堪用者實少，蓋坑戶祇於舊坑中收拾苴滓，雜以沙土，或盜他人膽銅，烹成片鋌，其面發裂，殆若泥壤，每斤價直計二百二十文省，徒費官錢。[336]
>
> He [Li Dazheng] also said: "recently I examined the yearly quota of the yellow-copper [i.e. ore copper] produced by the Censhui mine in Shaozhou. Although it is said to be 200 000 to 300 000 *jin*, however, the

332 SHYJG / ZG chapter 43, p. 132f. See chapter VI.1 of this thesis.

333 SHYJG / ZG chapter 43, p. 135f.

334 For quantitative information, see chapter VII.4 of this thesis.

335 SHYJG / XJ chapter 31, p.8.

336 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 21f.

> one which can be really used is little. This is because the mining households only collect some [ore] pieces in the old pits and mix them with sand and earth, or they steal other people's wet copper and boil it down until it becomes pieces or ingots, whose surface breaks like earth and mud. Every *jin* costs 220 *wen*, which is only a waste of governmental capital.

When several years later wet copper production began to decrease as well, new administrative measures needed to be taken to settle these matters in Censhui. On the one hand, 500 prisoners were sent to the mine to provide additional cheap labour for exploitation, on the other hand, the two production units for ore copper and wet copper were united under one roof. The last entry about Censhui, which dates from 1172 relates accordingly:

> [乾道八年]六月十六日，江璆狀：「前來曾措置韶州岑水場添槽作一百所，取膽水、膽土淋鐵成銅，[…] .照得韶州岑水場係分兩場場 […]。內黃銅場管鑿山取礦，烹煉黃銅，置武臣監官一員；膽銅場管浸鐵洗礦，烹煉膽銅，置文武臣監官各一員，內文臣監官改作檢踏官。遞年以來，兩色銅課皆不敷額，往往各分彼此，互有侵占。已將兩場併作一場，責辦監官依舊收趂外，緣岑水場承平人煙繁盛，其黃銅場監官階銜帶兵馬都監、主管煙火公事。今來既併為一場.[337]

> On the 16th day in the 6th month [of the eighth year of the Qiandao reign-period] [1172], Jiang Qiu reported: "Previously, at the Censhui mine in Shaozhou 100 groove workshops were added to use gall water and gall earth to leach [and thus] turn iron into copper. […] The Censhui mine in Shaozhou was [originally] divided into two institutions: The yellow-copper mine was in charge of chiselling into the mountain to obtain ore and to smelt it into yellow-copper. One military supervising official was established [for it]; the gall copper facilities were in charge of soaking iron and washing ore to smelt it into gall copper. One civil and one military official were established [for them], among whom the civil supervising official was changed into an 'on-the-spot-inspection-official'. In the recent years, the quota of the above mentioned two

[337] SHYJG / ZG chapter 43, p. 165f.

> institutions could both not be fulfilled. They always work on their own but one interlopes with the other. Now we have [already] united the both into one. Because the Censhui mine has a growing population, the military supervising official of the former yellow-copper mine was entitled as a military director-in-chief and 'controlling fire alarm'. Now two mines become one.

This last entry is the only source providing indications, that in Censhui not only leached copper was produced, but also soaked one. The enormous number of 100 grooves, however, which were apparently added for both wet copper methods, however, gives an impressive image of how huge production in Censhui must have been at least over several years.

C) Other Places

Besides the Yanshan and Censhui, another very important production centre must have been located at the Yongxing 永興 mines in Tanzhou 潭州, which is today the area of greater Changsha in Hunan Province. In this Prefecture, the region of present-day Liuyang 劉洋 still has remarkable copper deposits. Production statistics show, that impressive amounts of wet copper were produced in Yongxing as well[338] and in 1165, Li Dazheng subsumed it together with Yanshan and Censhui under the expression of China's "Three Big Production Places" (*san da chang* 三大場) for wet copper.[339] Unfortunately, little more can be found in the sources about the exact circumstances of wet copper production in Tanzhou and

338 See chapter VII.4 of this thesis.

339 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 21f.

also on the spot nothing allows further insights into the respective parts of Liuyang's Mining History any more.[340]

What is interesting is, that already in 1101, when wet copper was produced on a large scale not even for an entire decade yet, basically already all the locations (except the rather unimportant one in Chuzhou 處州), which would later play a role as larger or smaller sites of production were already identified. The *Song huiyao jigao* contains a respective entry for this year, which states:

> 徽宗建中靖國元年，以宣德郎遊經提舉措置江淮荊浙福建廣南銅事。經先以憂去官，至是服闋，自言：「昨在任日，常講究有膽水可以浸鐵為銅者韶州岑水、潭州瀏陽、信州鉛山、饒州德興、建州蔡池、婺州銅山、汀州赤水、邵武軍黃齊、潭州礬山、溫州南溪、池州銅山，凡十一處，唯岑水、鉛山、德興已嘗措置，其餘未及經理。將來錢額，愈見虧失。」[341]

> In 1101, You Jing was appointed to manage the copper affairs in the south. Before he went home because of the death of one of his parents, now the mourning period is full. He himself said: "Before, when I held that post, I frequently paid attention to [places with] vitriol water where iron can be soaked in to become copper, like in Censhui in Shaozhou, Liuyang in Tanzhou, Yanshan in Xinzhou, Dexing in Raozhou, Caichi in Jianzhou, Tongshan in Wuzhou, Chishui in Tingzhou, Huangqi in Shaowujun, Fanshan in Tanzhou, Nanxi in Wenzhou, Tongshan in Chizhou, all together eleven places. Now only Censhui, Yanshan and Dexing have taken measures, the others have not been dealt with yet. The quota for casting coins in the future will become more and more insufficient."

Map 6 indicates all the locations of the Production places for wet copper active during the Song period. From the places mentioned in the text, only

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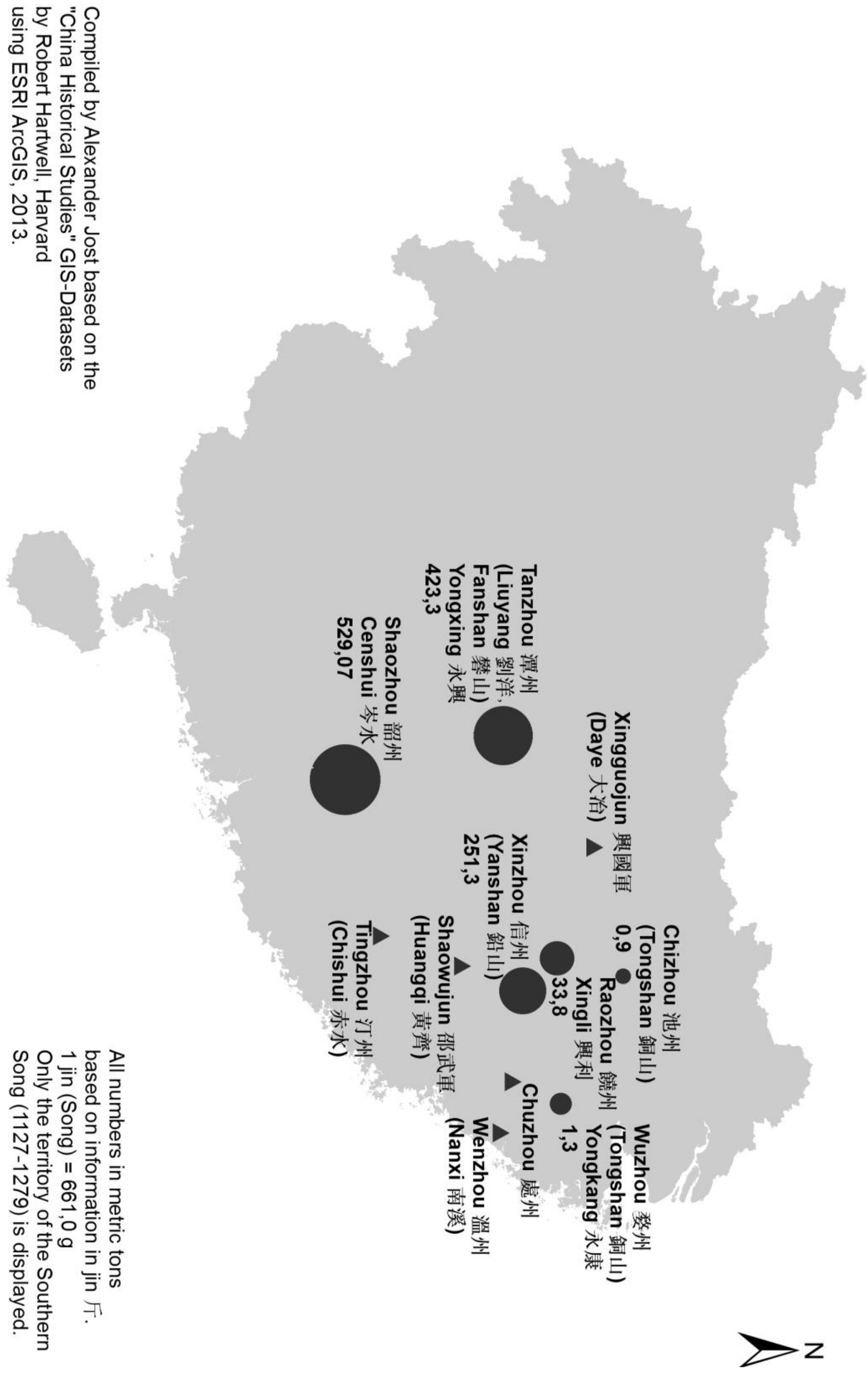
340 The author has visited Liuyang and Changsha in 2011 for several days and questioned local historians as well as representatives of the modern mine on various issues related to this topic but without any outcome.

341 SHYJG / SH chapter 34 (*kengye zalu* 坑冶雜錄), p. 25.

Jianzhou 建州 does not appear later as a wet copper producer. Where data are available, the sizes of the symbols indicate their importance measured by their annual wet copper production quota between 1111 and 1118. Names in brackets are locations, names without brackets are the names of the respective institutions.



Map.6: Annual wet copper production quotas (1111-1118).

4) Production Numbers

Figures, which survive do not allow us to retrace the entire quantitative development of wet copper production in Song China. Numbers for the country as a whole exist only for three different years or time periods:

Tab. 10: Data for the production quota and the actual production of wet copper for Song China as a whole.

Time	Quota in *jin*	Actual Production in *jin*	Source
1106		c. 1000 000	Wang Shengduo (2004), p. 150.
1111-18	1874427		SHYJG / SH chapter 33, pp. 19-20.
1162	212788		SHYJG / SH chapter 33, pp. 19-20.

Given the scarcity of this data and the fact that the success of wet copper production was, beside sufficient deposits of vitriol water and earth of course, highly depending on the weather in one year, these three numbers alone do not allow any further conclusions or speculation.

Fortunately for the particular case of Yanshan, more data are available, allowing to display some actual trends in the development of production and even to contrast the quota, which apparently often did not change over decades, with some actual production numbers, which may have showed great differences from the quota into both directions.

Especially the development of the quota reflects quite reasonably the events known to us from the entries in the *Song huiyao jigao*:[342] In the 1120s the easiest available resources began to become exhausted and capital increase did not keep track with price inflation, so the production declined. In the 1180s under the guidance of Li Dazheng, new production sites were established at Suoshanmen 鎖山門 and Zhuyewu 竹葉塢 resulting in a certain recovery.

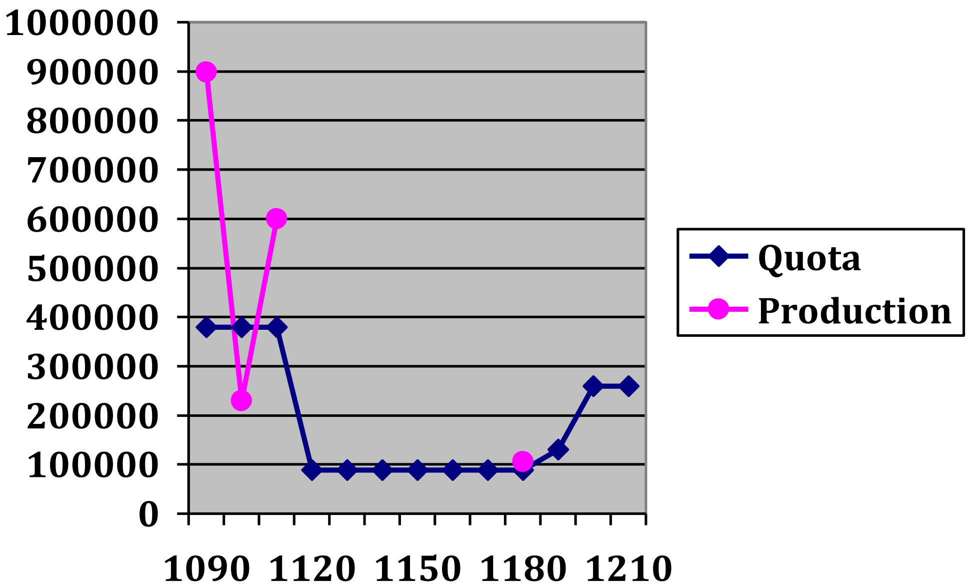


Chart 4: Development of the production quota and the actual production numbers for wet copper in Yanshan (1096-1216, slightly simplified).

[342] For more detail, see chapter VII.3A of this thesis.

Table 11: Data for the development of the production quota and the actual production numbers for wet copper in Yanshan (1096-1216).

Time	Quota in *jin*	Actual Production in *jin*	Source
1096	380000		Wang Shengduo (2004), p. 148.
1096-1102		898089.5	SHYJG / SH chapter 34, p. 25.
1102, month 1-9		172123.5	SHYJG / SH chapter 34, p. 25.
before 1115	380000	300000+	SHYJG / ZG chapter 43, pp. 132-133.
1115		600000+	SHYJG / ZG chapter 43, pp. 132-133.
1162	96536		SHYJG / SH chapter 34, pp. 19-20.
between 1127-1189	89000		Wang Shengduo (2004), p. 148.
1185		80000-90000	SHYJG / SH chapter 34, p. 27.
1186		100000-110000	SHYJG / SH chapter 34, p. 28.
after that	130000		ZQG, chap. 5, p. 1b.
at least until 1216	260000		ZQG, chap. 5, p. 1b.

One of the entries of the *Song huiyao jigao* showing providing the quota for the whole country is, however, also listing the contributions of the different production places as fixed in the quota of the years 1111-1118. This source thus offers the unique opportunity to compare the scale of wet copper production of at least some of the most important localities during one time period to each other. Map 6 is based on these data as well.

Table 12: Data for the contribution of the different production places as fixed in the quota of 1111-1118.[343].

Name of Production Place	Song Prefecture	Modern Province	Quota in *jin* (metric tons)[344]
Xingli 興利	Raozhou 饒州	Jiangxi	51 030 (33.8)
Yanshan 鉛山	Xinzhou 信州	Jiangxi	380 000 (251.3)
Censhui 岑水	Shaozhou 韶州	Guangdong	800 000 (529.1)
Yongxing 永興	Tanzhou 潭州	Hunan	640 000 (423.3)
Tongshan 銅山	Chizhou 池州	Anhui	1 398 (0.9)
Yongkang 永康	Wuzhou 梧州	Zhejiang	2000 (1.3)

One quantitative aspect of wet copper production statistics which is very interesting is the relation between the amount of copper produced with conventional ore smelting methods and the amount of copper produced with wet copper production methods. Fortunately, for two of the available numbers for the wet copper production in the entire country, comparable figures for conventional copper can be traced and have been calculated accordingly by Lung Tshun-ni:

343 SHYJG / SH chapter 33, pp. 19-20, Lung Tsun-ni relates these data to a year in the Shaoxing 紹興 reign-period (1131-1162). Wang Lingling, however, argues more believably that although the entry in the SHYJG was compiled then, it refers to the so-called "ancestoral quota" (*zu'e* 祖額) from the Zhenghe 政和 reign-period. During the Shaoxing period, production numbers must have already declined far below this level. See Lung Tshun-ni (1986), p. 121; Wang Lingling (2005), p. 104.

344 1 *jin* (Song) = c. 661g.

Table 13: The relation between copper production with conventional and with wet copper production methods in Song China.[345]

Item	Annual Production Quota in *jin* (metric tons)[346]	
	1111-18	**1162**
Wet Copper	1 874 427 (1 239.0)	212 600 (140.5)
Conventional Copper	5 181 835 (3 425.2)	29 860 (19.7)
Unclear Origin	1 002 (0.7)	20 710 (13.7)
Total Copper	7 057 264 (4 664.9)	263 170 (174.0)
Percentage of Wet Copper in Total	**26,6 %**	**80,8%**

From this calculation it becomes impressively obvious, that wet copper production was not only very important during the time of its alleged peak, when it provided more than one fourth of China's entire copper production, but also in later times of decline. When in 1162 China's wet copper production had been reduced to not much more than ten per cent of its former situation, conventional copper production had almost entirely vanished thus leaving the wet copper industries in a relatively even more important place than before.

It can be reasonably estimated that this relation may still have developed to a much more extreme direction, because in the 1180s with the opening of Suoshanmen and Zhuyewu, Yanshan's wet copper production could be multiplied[347] while no major changes in the

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[345] Lung (1986), p.121.

[346] 1 *jin* (Song) = c. 661g.

[347] See chart 4, table 11. and chapter VII.3A of this Thesis.

production of copper with conventional methods can be expected. In 1196, the *Song huiyao jigao* recorded:

> [慶元二年八月]二十七日，臣僚言：「鉟銷之禁，不可不嚴。且如輦轂之下，實為法令之始，孝宗皇帝固嘗親有訓戒矣。今乃列肆負擔，無非銅器，打鑄稜作，公然為業。又如建康之句容，台州之城下，專以古器得名，今則紹興、平江等處皆有之。江西之撫州專以七筋器皿得名，今則四明、隆興、鄂州、靜江等處皆有之。且今冶司歲鑄生銅，所入蓋自有限，其餘皆是取給於淋銅、浸銅。[348]

> On the 27th day [in the eighth month of the second year of the Qingyuan reign-period 1196], the court's officials said: "The prohibitions to melt down [metals] need to be executed most strictly. [...] Today, the coinage office every year [needs] new copper for casting [coins], but what comes in from [the collecting of copper objects] is very limited, the rest all consists in leached copper and soaked copper.

5) The End of Wet copper production

Wet copper production activities may have continued until the end of the Song Period and the Mongol conquest of China in the 1270s, but surely on a much lower level than at the beginning and at the end of the 12th century. Sources from this time are very few and the last indication for the existence of wet copper production shows only that at least until 1264 Censhui still had a quota to fulfil, although it is not clear if it still could. In another place it is recorded, that the Suoshanmen production site stopped operations in 1254.[349] There may have been different reasons for this decline:

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348 SHYJG / XF chapter 2 (*jinyue san* 禁約三), p. 127.

349 QT vol. 3, chapter *zicai* 資采.

Firstly, like for the copper ore for smelting, deposits for vitriol earth in workable places were close to be exhausted as well. As a consequence, also vitriol water was not available in suitable amounts anymore; secondly, during the end of the Song period, paper money enormously gained importance within the monetary system of the Song Dynasty.[350] Especially in the face of rising costs, the state may have tried to discontinue his strong involvement into copper production.

However serious this decline may have been and which of the reasons may have played a more important role, apparently with the Catastrophe of the Mongol invasion and the beginning of the Yuan period, wet copper production must have come to stop. The Mongols enforced the universal use of paper money for most Chinese regions and employed silver and gold for their external trade over the entire Eurasian continent. Only 72 years after the final end of the Song period, wet copper became a topic again, when the Yuan government intended an attempt to restore a copper-based currency in China.

As it had already been the case twice before during the Song period, the initiative was taken by the Zhang Family from Dexing.[351] Zhang Li 張理, a direct descendent of Zhang Qian, handed in a new copy of the *Jintong yaolüe* (Outline of copper soaking) to the Government. The preface to this book was later written by Wei Su 危素 and has survived, while the book itself is lost. The preface reads as follows:

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350 Peng Xinwei (1966), p. 367.

351 For more information on the relations between the Zhang family and the introduction of wet copper production, see chapter VII.2 of this thesis.

德興張理，從事福建宣慰司，考滿調官京師，會國家方更錢幣之法，獻其先世《浸銅要略》於朝。宰相以其書之有益經費，為復置興利場。至正十二年三月某甲子，奏授理為場官，使董其事。[…][352]

Zhang Li, a man from Dexing, after being transferred to the capital from his official post in Fujian, submitted his ancestor's book *Jintong yaolüe* (Outline of Copper Soaking) to the government just at the time when the State was reforming its currency policy. The Premier, considering the book beneficial to the national economy, reopened the Xingli Mine for him. One day in March 1352 A.D., the Premier requested His Majesty to appoint [Zhang Li] as the official in charge of the mine. […][353]

Apparently, when Wei Su wrote his preface to the book, the court had already accepted Zhang's suggestions and supported him to re-establish facilities for wet copper production. The text continues:

錢幣之行，尚矣。然而鼓鑄之無窮，產銅則有限。理之術乃能浸鐵以為銅，用費少而收功博，宜乎朝廷之所樂聞也。[…] 我武宗皇帝詔作至大錢，理之從祖諱懋與理之父諱遬以其書來，上皆命為場官。未及鑄印，而場司罷，至理復因，是蒙被異恩，幾於古之世官。惟其父子祖孫，顓於一事，其講之精、慮之熟可知己，何患乎冶鑄之無功、寶藏之不興哉！[354]

Using metal coins is now in favour. The amount of copper needed for smelting and casting is unlimited, but there is a limitation on copper production. [Zhang] Li knows the method of steeping iron to produce copper. This method costs less than smelting and can make a large profit, so it must be good news to the government. […] Our Wuzong emperor has issued an edict to produce "Zhida" coins. Li's granduncle Mao and Li's father Ti brought the book to [the imperial court]. The emperor appointed them both as mine officials. [However,] the mine offices were cancelled before the seals were cast. After Li contributed it again, [The Zhang family] received a special grace, almost like the hereditary officials in the ancient time. The grandfather, father, son and grandson had all concentrated on one thing, it can thus be imagined that

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352 WTPJ / JTYLX (WS) p. 11b-12b.

353 Translation partly by Lung Tshun-ni (1986), p. 120, partly by the author.

354 WTPJ / JTYLX (WS) p. 11b-12b.

their explanations are fine and their thoughts are thorough, why worry about no success of mining and smelting and no prosperity of treasure![355]

Although the Yuan court had apparently welcomed Zhang's suggestion and supported him, no further source from the Yuan period can be found, which mentions the technology. It should thus be considered likely, that his attempt yielded no long-lasting result. This may have been, because the government soon lost its interest again, because the places containing vitriol water and earth before were exhausted or because Zhang Li may not have possessed the same detailed knowledge and experience as his ancestors any more.

Zhang Li's initiative and Wei Su's preface are followed by a long silence of sources on the topic of wet copper production. More than one hundred years later, another short text passage indicates, that at least in the areas around the former production centres the idea of copper soaking may still have been existent:

江西信州鉛山銅井，其山出空青，井水碧色，以鉛錫入水，浸二晝夜則成黑錫，煎之則成銅。[356]

At a "copper well" in Yanshan, Xinzhou, Jiangxi, the mountain produces azurite and the colour of the well water is blue-green. If one takes lead and tin and soaks them in the water for two days and two nights, "black tin" is formed. After boiling, it becomes copper. [357]

The process described seems to be a newly discovered one, which was not in use during the Song period. One source from 1112, in which it is

[355] Translation partly by Lung Tshun-ni (1986), p. 120, partly by the author.

[356] XHLB /STZJ vol. 90, p. 15b.

[357] Translation partly by Lung Tshun-ni (1986), p. 120, partly by the author.

mentioned without any further explanation, that "iron and tin are required by the Censhui mines to produce gall copper"[358], remains a singular case and may just as well have referred to the use of tin for casting bronze alloys. Pure copper can, however, really be obtained from vitriol solutions by inserting tin and lead in a similar way as through iron.[359] It only remains the question, if it was in fact the familiarity with classical wet copper methods in Yanshan, which lead to the discovery of this reaction, or if the fact, that the source mentions only the precipitation of copper on lead and tin but not on iron is an indication that these methods were already largely forgotten at this time.

While during the Ming period (1368-1644) information on wet copper already only appears in reprinted or recompiled texts from the Song period or directly refers to them, during the early Qing period (1644-1911) it becomes obvious, that at least some authors do not understand or even not believe the information about wet copper when they encounter them in older texts. One such text can be found in the "Essence of Historical Geography" (*Dushi fangyu jiyao* 讀史方輿紀要) by Gu Zuyu 顧祖禹 from the year 1692. The passage is a part of the description of Shanghang district 上杭縣 in Fujian. This area encompassed the location of the wet copper production facilities of Chishui 赤水 in Tingzhou 汀州 during the Song period.

> 上有三池，名曰膽水，上下二池有泉湧出，中一池則蓄上池之流。相傳宋時縣治密邇，其地水赤味苦，飲則傷人，惟浸生鐵，可煉成鋼。後縣治既遷，其水遂變，不異常水。[360]

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[358] SHYJG / ZG chapter 43, p. 126.

[359] Lung Tshun-ni (1986), p. 124.

[360] DSFYJY, chapter 98, Shanghang District 上杭縣, Jinshan 金山.

> On the top of the mountain there are three ponds called 'the vitriol water ponds'. In the upper and lower two ponds there are springs flowing out, the middle pond is for gathering the water from the upper pond. According to the legend, during the Song Dynasty when the governmental seat of the county was close to this place, the water looked red and tasted bitter. If people drank it they fell ill, but when they put fresh iron into it, it could be refined into steel. Later, when the governmental seat moved away, the water changed and became ordinary.

Gu Zuyu may not have been a distinct mining expert but he was a respected scholar and surely one of the most knowledgeable persons on the topic of China's physical geography at his time.[361] Nonetheless he regards the idea that red-coloured water could transform iron as a mere legend and places it by relating its disappearance to the moving away of the district seat even closer to the realms of superstition. If the fact that the text shows that the iron turns into steel (*gang* 鋼) rather than copper (*tong* 銅) is due to a later character mix-up during printing or to his ignorance of the method as well cannot be judged but needs to be regarded possible.

The availability of older records may have been enough to save knowledge about the former existence of wet copper production methods from complete oblivion. But it was apparently not enough to let them survive as actively practiced methods or to even ensure people's believe in their actual applicability.

Interestingly, in 1667, 35 years before the *Dushi fangyu jiyao*, the book "China Illustrata" by Athanasius Kircher already included an observation which was related to the appearance of vitriol waters and the possibility of wet copper production as well:

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361 Yang Zhucai 楊柱才 (1996). entry "Gu Zuyu 顧祖禹", p. 237.

Lacus ferrum in cuprum vertens
Est in provincia Fokien Lacus, qui ferrum in cuprum vertit, totus viridi colore imbutus, cujus quidem rei ratio alia non est, nisi quod aqua tota vitrioli constet corpusculis; & color viridis ejus manifestum indicium est, cujusmodi in Europa quoque nullibi non occurrunt, in iis potissimum locis, copîosum è montibus cuprum extrahitur.[362]

A Lake which changes iron into copper
In the province of Fujian there is a lake, which changes iron into copper. It is entirely imbued with a green colour, a fact for which there is no other reason than that the water consists completely in vitriol, wherefore its green colour provides a manifest indication. Some of such [lakes] exist in Europe as well, especially in those places, where large amounts of copper are mined in the mountains.

This passage is remarkable, not only because it is a foreigner, who above all has never set foot on Chinese ground and thus needs to rely on other sources,[363] but also because it is the earliest explicit mention of the phenomenon after more than 300 years of silence. The fact, that information about it could even become available to a European without any very special concern about metallurgy is on the one hand of course a strong indication, that general knowledge about it must have existed here and there beyond the immediate vicinity of the respective regions. On the other hand it needs to be taken into consideration, that Kircher only mentions a "lake which changes iron into copper" but no human activities reflecting the intention to make use of this.

A serious attempt to make practical use of vague ideas, people may still have obtained from the knowledge that a lake or rivulet could make iron look like copper or that in the old time, wet copper may have been produced, can be traced much later in 1857. Interestingly it did not take

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[362] Kircher (1667) vol. 4, chapter 5, p. 174f.

[363] For the sources of Kircher's "China Illustrata", see Brancaccio (2007), p. 206.

place at any of the locations involved into wet copper production before, but as far away from them as Gansu. Zhang Jixin 張集馨, who was the Treasurer of this province, recorded the circumstances briefly among his private writings:

> 易念園［…］誤聽人言，云膽礬泡鐵，立可成銅，入奏試辦［…］今蔣立鰲在甘候補，與易念園為兩楚同鄉，承辦膽礬泡鐵之事。先於司庫領銀七百兩，又製錢若干串，拖延四年，交銅無幾。余到任后，蔣立鰲稟見，欲再請領庫款。余諭之曰："汝領款未清，安能再領？惟有將銅趕解，以清庫款"。蔣知余之不能欺，遂亦不復再請。而司中嚴札催銅，蔣亦置之不答。余博采輿論，僉為膽銅泡錢[falsely written for 鐵]，事涉懸虛，雖本草載有此說，從未經人試過。惟聞京師鞍轡鋪，製造鞦鐙，用膽礬水磨擦，鐵色似銅，然不能轉瞬，即復如舊，未聞鐵質隨之變化.[364]

> Yi Nianyuan[365] […] disbelieved somebody who said that when iron was steeped into gall alum it could immediately change into copper, [thus] he presented a memorial to make an experimental attempt. […] now Jiang Li'ao, an Expectant Appointee in Gansu who came from the same province like Yi Nianyuan, undertook the task of using gall alum to steep iron. He first drew seven hundred tael silver from the provincial treasury and then a number of strings of cash. However, after delaying for four years, he handed over only very few copper. After I came to the post, Jiang Li'ao came to meet me and wished to draw more fund from the treasury. I told him: "you have not yet paid off the last fund, how can you ask for it again? The only thing to do now is to deliver the copper in order to pay off the fund of the treasury." Jiang realized that I could not be cheated so he stopped asking. When the government urged him to hand over copper by strict letters, he just disregarded them. I have consulted public opinions and everybody says that the whole thing with steeping iron for gall copper is without foundation, although it is mentioned in one pharmacopeia but nobody has ever even really tried it out. I have heard that in Beijing one horse-gear shop uses vitriol water to scrub stirrups which can make the iron look like copper. But this cannot

364 DXHHJWL, p. 208f. Zhang was the Provincial Treasurer of Gansu (1857).

365 Yi Tang 易棠 (1794-1863), Courtesy name Nianyuan 念園, was a high official in charge of minting in Gansu at that time.

hold longer than the blink of an eye before it gets back its old colour and the material itself does not change anyway.

In the Xianfeng reign-period of the Qing dynasty, Gansu had its mint for casting "big cash" (*daqian* 大錢) thus procuring copper became necessary. Jiang's four-year-long experiment turned out to be unsuccessful and he died soon after. Although he still wished that his son could continue trying to produce wet copper, in the end nothing developed out of it.

Even as late as 1939, in the Gazetteer of Shanghang District in Fujian, the same place which as a part of Dingzhou 汀州 during the Song period regularly produced wet copper and which was also mentioned by Gu Zuyu 顧祖禹[366] during the early Qing period, an entry can be found implying, that at this time people still did not succeed to carry out the process successfully. The editor of the respective version of the Gazetteer relates there from his own experience:

> 清代福建因制錢缺乏，嘗用鐵錢。復幼時曾見人將鐵錢用礪石磨擦，以膽礬水没之，色如紅銅，惟擲之無音，不久色亦退。舊志所謂膽水浸鍊生鐵成銅疑亦此類耳。[367]

> During the Qing period, Fujian once used iron cash due to the lack of standard [copper] cash. When I [the author] was young, I have seen people rubbing this iron cash with sandstone (*lishi* 礪石), and then cover it with gall alum water (*danfanshui* 膽礬水). Its color then [became] like the one of red copper. However, [after] throwing it [onto the ground, it] made no sound, after no long time, the color also faded away. What the old gazetteer calls "making copper by soaking virgin iron in gall water (*danshui jinlian shengtie cheng tong* 膽水浸鍊生鐵成銅) must have been no more than this kind of thing either.

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[366] DSFYJY, chapter 98, Shanghang District 上杭縣, Jinshan 金山.

[367] SHXZ / 1939 chapter 36 (*zalu* 雜錄), p. 1b.

It is obvious that at this time wet copper production did not only not work, people also did not believe what they read in older accounts about the actual production of copper through wet production methods.

It is after all reasonable to believe that the latest during the Ming period, knowledge about the existence of wet copper production technology, not to speak of sufficient expertise to apply it, largely vanished even among well-read literati. If this is true for the intellectual conscious of China in general, there may be exceptions among the rural populations living in the immediate vicinity of the former production sites, which may have retained some practical knowledge. From the sources available at present, however, this can neither be confirmed nor denied. In the 20th century, however, wet copper production is practiced in China again with largely comparable methods. The situation and possible origins of this industry in modern China is discussed in chapter VIII.2B of this thesis.

VIII) Understanding Hydrometallurgy

1) Concepts of Understanding Metals

With its effect of creating wealth, supporting economic development and producing raw materials, which were most crucial in close to all fields of daily life, any knowledge promoting mining and metallurgy can with no doubt be classified as "useful knowledge" in the sense the term has gained in the context of Global Economic History.[368] As useful as it may have been, mining knowledge in pre-modern China was far from being "reliable". This means that, while down to the present day geology of mineral deposits and prospection technology need to live with a certain share of uncertainty in their methods but also in their practical abilities[369], in pre-modern China, finding, identifying and successfully treating minerals in order to obtain was an activity was an activity largely subject to methods of trial and error as well as to luck. A result of this was what Golas calls the "ad-hoc character of Chinese mining"[370]

368 As defined originally by Kuznets (1965) and recently recently brought back to attention in the context of the Needham question e.g. by O'Brien (2009) and Mokyr (2011).

369 Golas (1999), p.49.

370 Golas (1999), p.4.

This lack of certainty must, however, not imply, that no one would have tried to explain the phenomena anyone involved into the process of metal production could observe. To the contrary, in traditional China very complex and elaborate concepts were developed to understand and in the last consequence predict especially those aspects of mining and metallurgy, which exceeded the limits of recognition with the available means and methods. The variety of these concepts can be unravelled best by separating out four topoi, which display different, though never exclusive or contrary approaches to the topic.

A) The Topos of Mutual Production

The most superior and at the same time most basic topos ruling the traditional Chinese understanding of Nature is the system of the Five Elements (*wuxing* 五行). This Concept, which is from a modern perspective often regarded as Daoist due to the importance attached to it in the *Daode Jing* and forms the foundation of other larger concepts such as the Eight Trigrams or respectively the 64 Hexagrams of the *Yi Jing*. Within the circle of mutual production (*xiang sheng* 相生), the element "Metal" (*jin* 金) was placed in the middle between the two elements "Earth" (*tu* 土) and "Water" (*shui* 水) and thus stands in a productive relationship with both of them.[371] Transferred to the systems of the Eight Trigrams and 64 Hexagrams, the *Daye fu* picks up this concept directly in its first lines:

371 Needham (1956), p. 255.

堪輿奠位，峙嶽融瀆。合地四與天九，乾為金而兌屬。[372]

> When Heaven and Earth fixed the positions, they towered up high mountains and created long rivers [by melting]. Combining the earthly four with the heavenly nine, the Hexagram "Heaven" stands for metal, which, however, [also] belongs to the Hexagram "Lake".

In this place, Metal is, as described by the *Yi Jing*, belongs to the Hexagram *qian* 乾, with the basic meaning "heaven", its two main associations are "earth" and "lake", respectively "water.

The idea, that earth brings forth metal, is not difficult to follow, after all ores are usually mined in or under the earth. The relation with water is somewhat less self-evident but indeed finds its examples and explanations in popular believes as well as in the nature of deposits as well. This relation seems even more relevant especially in the context of wet copper production, which in essence means the production of metal from certain waters.

The association of water with metals, however, may as well be related to alluvial placer deposits of native metals, especially gold, which are argued to be worked no later if not even earlier than the earliest underground or surface mines.[373] As far as copper mining is concerned, it is remarkable, that especially in pre-modern times so called "secondary deposits" were worked successfully. Over long periods of Earth History, these deposits have been formed by the weathering and watering of igneous and primary rock deposits and their appearance is thus in fact due to the impact of water. Of course miners in traditional times may not have known that, but they may very well have noticed certain structures

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372 DYF, see chapter X.2b of this thesis.

373 Golas (1999), p. 239, Rosenfeld (1965), p. 195.

of the rock or the frequent availability of water around copper deposits.[374] Another factor may have been that water did not only in the nature around the deposits but – very much to the miners' displeasure – also inside the mines. This was the more likely the case the deeper one proceeded downwards and in many cases it kept miners from reaching the most promising parts of a deposit in greater depths, when their rather primitive means of water management were not sufficient to drain it any more. In these cases the association that it may have been the water, which produced the ore in the mountain is comprehensible. This thought may, however, also have provided the miners with some comfort or consolation when they had to retreat from flooded galleries.[375]

B) The Topos of Organic Growth

According to the circle of mutual production, earth could bring forth metal, respectively ores. This process of ores evolving inside the earth was often imagined as a process of growth following a similar pattern like the growth of organic objects in the nature. Consequently, around this idea of organic growth, various metaphors and images have been developed, which may be regarded as an independent topos by themselves, because they usually appear without any further references to the topos of mutual production. Alone in the *Daye fu* this is the case in several places:

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374 Golas (1999), p. 236, In this place Golas refers to ideas suggested to him by Lung Tshun-ni as well as to similar understandings in pre-modern European mining like the remark of Biringuccio: "[…] I had always understood that water was the primary and peculiar companion of minerals.[…] All mountain, from which abundant waters spring, also abound in minerals." (Smith & Gnudi (1959), p. 20f.).

375 Golas (199), p. 236.

落亭之紫，爛焉暕暕。春蒲闖水，茸芽尚短。樂安精鏐，胎瑞坑谷。[…]渠陽澤銑，毓奇溪洞。[376]

> The purple [gold] of Luoting , shining there so bright; like the bulrush in spring stretching its head out of the water, with its downy buds still being short. The fine, pure [gold] of Le'an , auspiciousness growing like an embryo in pits and ravines. […]the lustrous gold of Quyang, rare [preciousness] gestated in rivulets and grottoes.

These verses already include two different organic images, which could be attributed to ore deposits:

One is, to consider the ore as a plant growing from the deeper parts of the earth towards the surface. In this particular case the image of the fine, tender shoots of the bulrush additionally convey the idea of a certain breakable beauty of the gold veinlets. This image also manifests itself in the frequent use of the word "sprout" (*miao* 苗) for long and thin veinlets of ore.

The other one is still closer related to the concept of the Five elements: Within the circle of mutual production, the producing element is always regarded as the mother, the produced element as the child. Consequently, in this case, the earth is the mother while the ore is the child. Another example of this constellation is provided by the *Daye fu* is the following:

監務坑井，殆幾萬計。[…]舉斯以旃，特其几例。然或鐵山之孕銅，或銅坑之懷金；[…][377]

> As to the adits and pits to be inspected and cared for, they probably amount to close to ten thousand. […] Those mentioned here in praise, are only representative examples. Sometimes iron mountains are pregnant with copper, or copper adits hold gold in their womb; […]

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376 DYF, see chapter X.2g of this thesis.

377 DYF, see chapter X.2f of this thesis.

This topos, for which many more examples can be given, however, does not always function according to the same pattern. While within the context of the Five Elements and the two quotations from the *Daye Fu* the earth or respectively the surrounding environment like the grottoes or the mountains are the mother, other forms of this image can be observed as well. It is for instance reported, that according to traditional miner's believes in Yunnan "the natural native copper (*tiansheng tong* 天生銅) found in the cracks of the rock was the mother of the copper and should not be removed,"[378] because otherwise the surrounding copper ore could not continue to grow and would be exhausted one day. The "Representative answers from the region beyond the mountains [in the south]" (*Lingwai daida* 嶺外) from the Song period refer to native gold nuggets as "mother" as well. In contrary to the example above, however, this text does not see any reason to not pick these "gold mothers" up to enrich oneself:

> 廣西所在產生金[…]有大如雞子者，謂之金母。得是者，富固可知。[379]
>
> Some places in *Guangnan Xilu* produce raw gold […] there are [pieces] as big as chicken eggs which are called gold mothers (*jinmu* 金母). It can be imagined how rich the one becomes who finds them.

[378] Golas 236, after Li Chung-chün (1982), p.3 and Yen Chung-phing (1957), p. 59.

[379] LWDD chapter 7, p. 10a.

C) The Topos of Human Impact

While the former two topoi almost entirely dispense any kind of human or spiritual action, the third one is defined through a combination of human action and supernatural response. According to this model, the treasures of the earth offer themselves to man if he behaves in a way that he deserves it. In this context "man" can stand for a single person or mining community, but also for the country or respectively all-under-heaven (*tianxia* 天下).

Examples of small scale

The most basic idea behind this topos is, that the geographical entities containing ores, usually mountains, are inhabited and controlled by spirits of different kinds. If these spirits are pleased, they can be very generous, but if they are angered, they cannot only withhold all their treasure but even bring death and destruction over the miners and their enterprise.

It was thus a widespread custom to offer sacrifices to these spirits at certain times of the year or for instance when a new shaft or adit was opened. Besides these temporary activities, at bigger mines shrines and temples were established for permanent worship. Not only many sources from the Song period mentioning such buildings in the context of conventional mining can be found, there are also two reports about the establishment of two temples spirits with a relation to wet copper production.

Fig. 33: Sacrifice to the spirit of a coal mountain, illustration in an album from the late Qing period. Source: Bibliothèque Nationale de France, Signature: Oe117, pl.1. Contained in Golas (1999), p.405.

One is the "Temple for the God of the Seven Treasures" (*Qibaoshen ci* 七寶神祠), which was built at the Censhui mine, the biggest producer of leached copper during the Song period:

> 七寶神祠
> 在韶州曲江縣岑水場。哲宗元符二年賜額。徽宗崇寧五年八月封豐應侯。
> 孝宗乾道八年二月加封通利豐應侯。[380]

[380] SHYJG / L chapter 20 (*zhu cimiao* 諸祠廟), p. 144f.

> Temple for the God of the Seven Treasures
> In the Qujiang District of Shaozhou lays the Censhui mine. In the second year of the Yuanfu reign-period (1099) of emperor Zhezong a tablet was bestowed upon it. In the eighth month of the fifth year of the Chongning reign-period (1106) of emperor Huizong, [the god] was ennobled as a Fengying marquis. In the second month of the eighth year of the Qiandao reign-period (1172) of emperor Xiaozong, he was again ennobled as a Tongli fengying marquis.

1099 may have been the year, when large-scale wet copper production had just started in Censhui and by this an attempt was made to lead the mining region back to old splendour. It is likely that it was on this occasion, that a tablet was sent to the temple to express governmental support for the enterprise and of course to please the responsible god so he would provide good vitriol water and earth in abundance. He obviously did so, as the following sentences indicate and Censhui developed into the biggest producer of wet copper throughout the empire.[381]

There must have been at least one other temple at the Censhui mine, because only five years before the tablet was sent to the *Qibaoshen ci*, the famous poet Su Shi 蘇軾 passed through Censhui and wrote a poem about the "Moonlight Temple (*Yuehua si* 月華寺), a place of worship apparently mainly visited by miners. This poem does not contain any information about wet copper, most likely because production had not begun yet, but it reflects very well through the eyes of a person very critical to mining, how mining may have been seen as an interaction between man and heaven:

381 More information on the development of the Censhui mine see chapter VI I.3b of this thesis.

月華寺
（寺鄰岑水場施者皆坑戶也，百年間蓋三焚矣。）
天公胡為不自憐，結土融石為銅山。
萬人採斲富媼泣，只有金帛資豪姦。
脫身獻佛意可料，一瓦坐待千金還。
月華三火豈天意，至今茇舍依榛菅。
僧言此地本龍象，興廢反掌曾何艱。
高巖夜吐金碧氣，曉得異石青斕斑。
坑流窟發錢涌地，暮施百鎰朝千鍰。
此山出寶以自賊，地脈已斷天應慳。
我願銅山化南畝，爛漫黍麥蘇惸鰥。
道人修道要底物，破鐺煮飯茅三間。[382]

The Moonlight Temple
(This temple is next to the Censhui mine, the donators are all mining households. It has been burnt three times within one hundred years.)

Why does not the ruler of heaven cherish himself?
He placed earth and melted stones into a copper mountain.

Ten thousand people dig and strike while the earth god cries.
Only [precious] metal and silk are supplied for the rude and the evils.

Get free to present in front of Buddha, the situation is expectable.
One tile enjoys to be paid back by one thousand [pieces of] metal.

The Moonlight temple has had three fires, isn't this the will of heaven?
Until now the reed sheds are still overgrown with grass.

A Monk said this place has had dragons and elephants.[383]
To rise and to fall like turning a hand, has this ever been difficult?

The high cliff spits out metal and blue-green *qi* in the night.
In the morning particular stones have obtained a blue-green pattern.

Cash flows out of pits, comes out of caverns and gushes out of the earth.
The one who invests one hundred *yi* [24 *liang*] at sunset, he becomes one thousand *huan*[384] back the next morning.

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382 DPQJ vol.22.

383 This expression stands for eminent and learned monks.

> This mountain produces treasures to damage itself,
> The veins in the earth are already broken; as a response, heaven
> becomes grudging.
>
> I wish the copper mountain could change into farmland,
> prosperous broomcorn and wheat can rescue those who have no
> brothers and who have no wives.
>
> What things do monks need to cultivate themselves? Just a broken wok to cook rice and three shacks.

In Su's understanding, mining is already a crime against heaven's will per se. Miners should not hope to receive divine support for their activities and monks should not enrich themselves with the miners' money. Heaven disapproves of their behaviour and thus lets the ore veins of the miners break off to grudge their profit and burns the monks' temple down three times within one hundred years.

The third example is much more and more explicitly related to the production of wet copper, it is called the "Temple for the Gall Water God of the Gushing Spring" (*Yongquan danshuishen ci* 湧泉膽水神祠). For this house of worship the following is reported:

> 湧泉膽水神祠
> 在信州鉛山場鎖山門。壽皇聖帝乾道八年五月賜廟額「金泉」[385]
>
> Temple for the Gall Water God of the Gushing Spring
> In Xinzhou at the Yanshan mine lays [the place] Suoshanmen. In the fifth month of the eighth year of the Qiandao reign-period [1172] an tablet was bestowed upon it by the emperor inscribed with the words "metal spring".

[384] *Huan* 鍰 is an ancient unit of account, the value is not clear. 1 000 *huan* must, however, not have been few.

[385] SHYJG / L chapter 20 (*zhu cimiao* 諸祠廟), p. 114.

Fig. 34: Modern mining temple on a copper mountain near Daye 大冶, Hubei Province. Source: Photo by the author.

But it was not only through worship and sacrifice, that traditional Chinese miners showed their respect and gained the favour of the mountain spirits. Another aspect was, not to anger them by misbehaviour. Such misbehaviour could consist in the pronouncing of taboo words[386], but also for instance in the forceful removal of forbidden rocks or the creation of loud noises in the wrong places.[387] Hong Zikui may be picking up such taboos in a not entirely respectful manner in his *Daye fu*, when he describes vividly:

386 Golas (1999), p. 406.

387 Golas (1999), p. 405; Rocher (1879/80), p. 245.

磅磅馳霆，剥剥灑雹。丘示掩耳而疾遯，木客捧心而竦愕。膽寒野伏之夔罔，魂褫泥蟠之龍蠖´。[388]

"Bong, bong" rolls the thunder, "bak, bak" crackles the hail [(sounds of beating the rock)]. The mountain spirits cover their ears and escape hastily and the forest spectres grasp their hearts, scared and in deep fear. Frozen gets the courage of the Kui and Wang crouching in the wild and absconding is the soul from the dragons and worms coiling in the mud.

An inscription memorising the efforts of the official Li Dazheng 李大正 concerning the establishment of the prosperous copper soaking facilities at Suoshanmen 鎖山門 near Yanshan provides another very suitable example for this topos:

其泉在鎖山為溝特一千有二{時以十有二}，豈天地之藏亦將待人而發耶。蓋是泉之復，實公奉詔明日。[…] 矧夫隴西公之為是役也，水復其初，民忩其勞，是天與人交相之也。是可銘也。[389]

This [one] spring became twelve gutters at Suoshan, isn't it so, that the treasures of the heaven and the earth wait for one particular person and only then show up? The recovery of the spring was [exactly] on the next day when Li had received the edict. […] Li's project made the water recover like before and made the people forget their toil, this was an interaction between heaven and human, which makes it worthy to be inscribed.

Examples of large scale

What is true for single mines and their particular religious and para-religious believes, can also be transferred analogically on the country if not the world as a whole. What matters in this case most from the human side is, that rule is executed legitimately and in perfect harmony with the requirements of Heaven and Earth. If this is the case, blessings of various

388 DYF, see chapter X.2k of this thesis.

389 YS, chap. 7，pp. 93a-94b & YSXZ / QL, chap. 12, pp. 69b-70b.

kinds may be the result, which are preceded by auspicious signs. In the best case, this can lead to a *Shengshi* 盛世, which is best to be translated as "Golden Age". The rewards such an age brings to the emperor and his people are in the first line blessings to the agriculture in the form of favourable weather and the absence of catastrophes. In analogy to the crops flourishing above the earth, ores grow under the earth and disclose their locations to the people. In its final passage, the *Daye fu* describes the virtues of the perfect emperor and his governing in harmony with the principles of nature. The resulting reward of such a beneficent rule is narrated culminating in the following words with which the *Li Ji* describes the rule of the sage kings:

> 天不愛道，聖賢興兮；地不愛寶，稼穡登兮。人不愛情，富壽且安兮。[390]
>
> If Heaven does not grudge its methods, saints and sages appear. if the Earth does not grudge its treasures, cultivation and harvest [are] abundant. If men do not grudge [the regulation of] their feelings, there will be wealth, long life and peace.[391]

The characteristic sentence "the Earth does not grudge its treasures" (*tian bu ai bao* 天不愛寶) refers to a flourishing agriculture as well as to a prospering mining industry. When Zhang Jia, the son of Zhang Qian wrote the preface to the *Jintong Yaolüe*, he used the same expression to show his gratitude for his successful attempt to produce copper from vitriol water:

[390] DYF, see chapter X.2r of this thesis.

[391] Translation by Legge (modified by the author), see LJ / Legge, p. 392f.

驚喜嘆頌，竊謂聖明述作，德侔覆載。人與天從，地不愛寶。千古所未覩之祥，一旦發為聖世之瑞。麒麟鳳凰，謏書休應；醴泉靈菌，無補事功。大哉！此時實為難遇。[392]

Joyfully Surprised, I sigh and praise the virtue of the saints' works which is as great as Heaven and Earth. Man and Heaven are in harmony, the earth does not grudge its treasures. Auspicious signs, which have never been seen for thousands of years, now suddenly appear in the present age. Qilins and Phoenixes cannot compare to this auspiciousness; sweet streams and Lingzhi mushrooms cannot compare to this achievement. How huge! This time is indeed a rare chance!

D) The Topos of the Magic and the Mysterious

General patterns of understanding concerning the nature of wet copper production – as far as it could be understood – seemed to have been comparable to the ones of conventional metal production. Where these patterns could not be applied analogically, the idea of magic or the or the confession of the limited ability of men to completely comprehend the miraculous works of nature took their place. This is for instance the case when the *Daye fu* concludes its chapter on copper leaching with the following words:

幻成寒煖燥濕不移之體，疑刀圭之點鐵。[393]

Magically an object is completed, which does not change by cold, heat, dryness or humidity, as if iron were touched [and turned into gold] by a powerful essence (*daogui* 刀圭).

In this place, the connection not only to magic in general but also to Daoist alchemy in particular becomes obvious. This is of course also due to the fact that Hong Zikui is probably aware of the method's origin in Daoist

392 JDZSZP / JTYLX(ZJ), p. 40.

393 DYF, see chapter X.2r of this thesis.

practices,[394] at the other hand in this particular place inside the poem it also represents a general consciousness of the inability to completely understand the process.

Not only the chapter on copper leaching, also the poem as a whole ends with such a confession, now of course not only in relation to wet copper production, but to all the phenomena discussed in the poem which culminate in the *tian bu ai dao, di bu ai bao*[395] passage:

> 化工之巧，莫窮其端兮。[396]
>
> As to the ingeniousness of the operations of nature in producing changes, nobody will ever find out the root of the matter.

When Shen Gua 沈括 mentions the phenomenon in his famous *Mengxi bitan* 夢溪筆談 (Brush talks from Dream Brook) recurring to an older text from the late Tang Dynasty[397], he comes to a very similar conclusion:

> 信州鉛山縣有苦泉，流以為澗。挹其水熬之，則成膽礬。烹膽礬則成銅；熬膽礬鐵釜，久之亦化為銅。水能為銅，物之變化，固不可測。[398]
>
> In Yanshan county in Xinzhou there is a bitter spring, which flows down as a mountain stream. If one ladles out its water and boils it, it becomes vitriol (*danfan* 膽礬), which becomes copper when cooked. The iron fu pot, in which the vitriol has been boiled, also changes into copper. If water can change into copper, [this shows that] it is impossible to calculate the changes of nature.

394 See chapter III,1 of this thesis.

395 See chapter VIII,1c of this thesis.

396 DYF, see chapter X.2r of this thesis.

397 ZTDZ / DFJY.

398 MXBT chapter 25 (*zazhi er* 雜志二), p. 276f.

2) Discourses on Wet Copper

The topoi and concepts mentioned above were all in one way or another parts of one integrated system, they rather supplemented than contradicted each other and by doing so created an explanatory horizon for the phenomena anyone involved into mining or other stages of metal production necessarily witnessed.

When it came to the role of metals, especially of wet copper, in state and society, however, and political decision had to be made, discourses took place on another level and became more controversial.

A) Between Secret and Public Knowledge

A first trace of this controversy appears already at least five years before Zhang Qian and Zhang Jia handed their *Jintong yaolüe* over to the government and thus launched the fast rise of wet copper production on a large scale.

During his time as vice minister at the ministry of revenue, which was between 1087 and 1089, Su Zhe 蘇轍, the brother of the famous poet Su Shi 蘇軾 or Su Dongpo 蘇東坡, received a visitor, who was eager to introduce a so-called secret method (*mifa* 祕法) to him. Later he commented on this matter himself in the following way:

> 不聽祕法能以鐵為銅者
> 有商人自言於戶部，有秘法能以膽礬點鐵為銅者。予召而詰之曰："法所禁而汝能之，誠秘法也。今若試之於官，則所為必廣，汝一人而不能自了，必使他人助汝，則人人知之，非復秘也，昔之所禁，今將遍行天下。

> 且吾掌朝廷大計，而首以行濫亂法，吾不為也。”其人黽俛而出，即詣都省言之。諸公惑之，令試斬馬刀，厥後竟不成。[399]
>
> How I did not believe in a secret method to turn iron into copper:
> There was a merchant who reported to the Ministry of Revenue that he knew a secret method to convert iron into copper by for using gall vitriol (*danfan* 膽礬). I asked him to come before me and I scolded him like this: "This method is forbidden and only you can carry it out, it is thus indeed a secret method. If it is now officially tried out by the government, [knowledge about] how it is done will definitely spread. You alone cannot handle it and thus you have to be helped by others. Then everybody gets to know about it, it would thus be no longer a secret. What has been forbidden before, now should be spread all over the world. I, who control the important affairs of the state, should take the lead to disturb the law by acting reckless, this is a thing I will not do." The merchant left reluctantly, immediately went to the Department of State Affairs (*dusheng* 都省) and reported about [the method] to the officials [there]. They doubted about it and ordered him to test it with a horse slaughtering knife (*zhanma dao* 斬馬刀). However, it did not work in the end.[400]

It does not become clear from the text, nor from any other source, if the wet copper method at this time is already known but explicitly forbidden or if it is forbidden as a part of a general regulation of forbidding "secret methods". The second case is somewhat more likely, because otherwise the officials at the department of state affairs would not have to try it out and fail, but would be likely to already know about it and about the fact that it could work. The interesting point is, that at this time, "secret" knowledge and "public" knowledge were apparently very clearly divided. Su Zhe does not reject the merchant because he doubts the efficiency of the method or regards it as uneconomic, but because it is a "secret method"

399 LCLZ chapter 5, p. 27.

400 Translation by Lung Tshun-ni (1986), p. 117, modiefied by the author in various places.

and thus it needed to be avoided that it became public by state action and spread among the commoners. It is of course hard to estimate, if this is the only reason of Su's refusal or if he may also have been afraid, that if there would be a commonly known method among the population to produce copper (or an indistinguishable fake of it) out of any water, this would have devastating consequences for a monetary system based on copper monopolized by the government. This would also explain the policy of containment towards other secret methods of Daoist alchemists, because many of them were aimed at finding new ways to produce gold or silver, an attempt which, if successful would have had similar consequences.

It was thus necessary for any method of wet copper production to first leave the secret corner and become, in the closest sense of the word, presentable at court. When only few years later the *Jintong Yaolüe* was in fact presented at the court, Zhang Jia consequently chose his words diligently:

> 萬物之理，非聖人莫窮；萬物之用，非聖人莫制。窮而制之，曲盡其性。故《神農本草》載：石膽能化鐵為銅。妙極神通有至於此，信哉！百工之事皆聖人作，然其說具存，其所以化之之術，綿歷數千百年，未有能知之者。往往爐修鼎煉之事，皆為虛語。[401]

> The principles of nature, only the sages can explore; the uses of nature, only the sages can control. By exploring and controlling them, they struggled to thoroughly understand their character. The old "Shennong bencao" has recorded that stone alum can turn iron into copper. Magical and miraculous, how unbelievable! The ones who did these hundreds of works were all sages. Although the descriptions still exist, for hundreds and thousands of years there has been no one who could have mastered the art of actually carrying them out. The practices of the furnace-builders and cauldron-smelters are often just all empty talk.

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401 JDZSZP / JTYLX(ZJ), p. 40.

He draws a clear division line between the respectable truth, which was explored thousands of years ago by the sages and the useless experiments of contemporary or almost contemporary alchemists. His father directly obtained his discoveries by reading the *Shennong Bencao* which reflects the knowledge of these sages and becomes thus directly linked to them rather than to the alchemists with their "secret methods" disapproved by the government. Like this, he could hope to avoid being treated like the merchant who came in front of Su Zhe. This does of course not necessarily need to mean that his father's invention was in fact not connected to alchemist practices and the respective "secret" knowledge.

When Zhang Tao handed the book over to the court again, he repeated this division between the sages or immortals, who through reasoning and the investigation of the principles of nature obtained something like "reliable knowledge", and the alchemists, who applied only experimental methods and used their knowledge for simpler purposes.

> 謹按《本草》著石膽，謂神仙能以化鐵為銅，成金銀。故方術之士競盡力於此，然不探其理，類皆求之爐火之間，以為丹藥之用。[402]
>
> The *Bencao* has recorded that the immortals could use the stone alum (*shidan* 石膽) to turn iron into copper, as well as to produce gold and silver. So the masters of [all kinds of] supernatural arts exhausted themselves in pursuing it. However, they did not search for the principles but only experimented between furnaces and fires to produce pills and drugs.

[402] JDZSZP / JTYLHX(ZT), p. 41.

Fig. 35: The Alchemist Ge Hong 葛洪 in his Laboratory, scroll painting, time unknown. Source: Needham (1983), p. 216.; Song Daren (1937).

In the following, Zhang Tao continues to dwell on the difference between Zhang Qian's achievements, and the practices of the alchemists. While before especially the trial-and-error character and the lack of deeper understanding of things by the alchemists was contrasted to the systematic truth-seeking of the sages, in this passage he adds the argument, that his activities are destined to support the country and bring benefits to the people, while the aim of the alchemists consists only in the pursuit of their own selfish interests.

> 能闡造化之機，發天地之秘，成至簡至易之法，為無極無盡之利，上以佐國，下以惠民，豈若方士區區為一己之私，而其效又豈特成金銀之比哉！［…］以示非常之瑞而假手於曾祖以發之。[403]

> Being able to explain the system behind the productive changes of nature, to uncover the secrets of heaven and earth and to form them into easy and simple method, which brings endless and inexhaustible benefits, upwards by supporting the country, downwards by helping the people, how can this be the same with the alchemists who only have their own interest in mind? How can its effect be compared especially by the mere creation of gold or silver? […] [Heaven and Earth] showed extraordinary auspices and instrumentalised great-grandfather to develop them.

As already described above[404], the Zhang family succeeded with their request to establish wet copper production facilities of a larger scale in their hometown Dexing as well as in the neighbouring District of Yanshan.

Choosing the right words in his preface was surely not the predominant reason for their success, though it may have been helpful muzzling the adversaries of their attempt.

B) Wet Copper, the Court and the Government

Nothing is known about the further circumstances and events around the admission of their request. It can, however, be guessed that the fact that the Zhang Family succeeded in 1094 where another applicant had been refused only several years earlier, had something to do with path-breaking changes, which took place at the court in the years 1093 and 1094.

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403 JDZSZP / JTYLHX(ZT), p. 41.

404 see chapter III of this thesis.

Fig. 36: Emperor Zhezong 哲宗 and empress dowager Xuanren 宣仁 of the Song Dynasty. Source: Wikimedia Commons.

Emperor Zhezong 哲宗 had officially ascended the throne already in 1085, short before the unknown merchant introduced the wet copper method to Su Zhe, at the age of nine. Rule was de facto taken over by the empress dowager Xuanren 宣仁, who withdrew most of the reforms before established by Wang Anshi 王安石 under Emperor Shenzong 神宗 and supported officials advocating rather conservative positions. It can be imagined, that neither she nor her advisors would have welcomed the introduction of coins produced by a completely different method than centuries before. In 1093, the empress dowager passed away and Zhezong began to rule the country in person at the age of 17.

With the beginning of his new Shaosheng 紹聖 reign period still in the year 1093, he began to readjust the political direction again, re-established many of the regulations, which belonged to the reform attempt of the now deceased Wang Anshi and replaced conservative officials by reformist ones. One of the first and most prominent examples of this policy of replacement was in fact Su Zhe, who had protested strongly against the emperor's return to the reformist side. He was dismissed from his position as vice-director of the Chancellery (*menxia shilang* 門下侍郎) and sent off to a minor post in Ruzhou 汝州, part of the present-day Pingdingshan 平頂山 in Henan.[405]

The Zhang family must have chosen this historical moment with the greatest will for political reforms and the overthrow of conservative positions very deliberately. This can also be seen from the words, which Zhang Jia uses to explain his timing and to clarify his loyalties:

> 紹興甲戌，天子聖欽日躋，親覽庶政，袪除殘蠹，纂條先帝之遺法，登用耆舊，作新百度。四海承風，跂首象魏，謳歌鼓舞，真萬物咸若之時也。[406]
>
> In the *jiaxu* year of the Shaosheng reign-period, [1094], the son of heaven's respectable and holy sun has risen and he himself has taken over the numerous [duties of] ruling. He has purged out the oppressive worms and he has re-established the laws handed down by the last emperor. He has employed the old and honourable statesmen [again] and he has set up hundreds of new regulations. The world has become civilized and [everyone] looks up to the imperial court singing praise and dancing to the drums. This really is a time when everything seems to be in harmony.

Emperor Zhezong died only six years later in 1100 at the age of only 24. Under the following reign of Huizong 徽宗 his reformist policies continued with varying efficiency until the sudden end of the Northern Song period in 1126. When policies were changed again later, the decision to apply wet copper methods for the benefit of the mints had already proved to be very efficient and useful and thus persisted through the following decades and centuries without any setbacks in political favour.

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405 Twitchett & Smith (2009), p.531ff.

406 JDZSZP / JTYLX(ZJ), p. 40.

IX) *Wet Copper in other Places and Times*

1) Wet Copper outside of China

A) Early Knowledge on Wet Copper outside of China

Barely any doubt can be cast on the fact, that the first recognition of the phenomena fundamental to the successful execution of wet copper production, which still existing sources recorded, took place in China.[407] However, about 200 years later the first non-Chinese source, in the year 77 A.D., a related observation appeared forming a part of the famous *Naturalis Historia* of Pliny the Elder:

> Metallorum omnium vena ferri largissima est Cantabriae. Maritima parte, qua oceanus adluit, mons praealtus, incredibile dictum, totus ex ea materia est, ut in ambitu oceani diximus. Ferrum accensum igni, nisi duretur ictibus, corrumpitur. Rubens non est habile tundendo neque antequam albescere incipiat. Aceto aut alumine inlitum fit aeri simile.[408]

> Of all the mineral deposits, the iron veins of Cantabria are the largest ones. In its coastal part, which is washed by the sea, there is – incredible to say- a very high mountain entirely consisting in this material, as we have already reported in our description of the Oceans. If this iron is heated by fire, it will perish if it is not beaten. As long as it is red it

[407] For the earliest records in Chinese sources see chap. III of this thesis.

[408] Pliny the Elder, Naturalis Historia 34.57+58.

> cannot be forged, not before it starts to become white. If it is coated with vinegar or alum, it becomes similar to copper.[409]

It is interesting to see, that Pliny does not ascribe the special process he witnessed (or of which he noticed that others witnessed it) to the characteristics of the vitriol or of whichever else liquid solution used to coat the iron, but rather to the iron itself. Although it seems clear, that the description of the phenomenon is in fact related to the wet copper method, this makes it unlikely to assume that any further investigations were undertaken on this matter, let alone that it would have been carried out in any systematic way.

Another aspect becoming obvious from this description is, that for any further development of this technique beyond the pure observation, more distinct ideas about the identification of suitable copper sulphate bearing materials –consciously or by chance– would have been necessary. In the European and Middle Eastern antiquity this was only partly the case. Vitriols as a category encompassing a greater variety of substances were already identified in Ancient Mesopotamia and Egypt the latest by the 7th century B.C.[410] Within the Hellenistic context, Bolos of Mendes[411] and Dioscorides Pedanius[412] were the first ones to define the term for the graeco-roman world. From these definitions it can be seen, that the Greeks already believed vitriols to be cupriferous substances. The earliest Greek term employed was χαλκανϑων, which is clearly derived from the early

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409 Translation by the author based on the german translation of this text passage by Roderich König. See Plinius / König (1989), p. 105.

410 Karpenko & Norris (2002), p. 997.

411 Bolos of Mendes / von Lippmann (1919), p.42.

412 Dioscorides Pedanius / Gunther (1959), p. 639f.

term χαλκός, meaning "copper" or "bronze". However, this believe must not necessarily have been due to the fact that the observed material was in fact a copper sulphate, Karpenko and Norris assume much more, that most of the substances assigned this name were actually called like this due to their appearance near the copper mines of Cyprus, a place ironically particularly rich in iron vitriols. Furthermore, the Latin expression *atramentum sutorium* referred to its use as a blackening agent for leather – a function that could not have been fulfilled by copper sulphates, but only by iron sulphates.[413]

It was only through the later categorizations of Arab authors like Jabir ibn Hayyan (alias "Geber"), Muhammad ibn Zakkariya ar-Razi, Abdallah ibn as-Sina' (alias "Avicenna") or Muhammad ibn Ibrahim al-Watwat that the varieties of vitriols were further specified and categorized. This development of categorization apparently did not include the recognition of some vitriols' ability to precipitate as copper on iron surfaces.[414]

Though no sources from this in the widest sense of the word alchemist body of literature are known before at least the 15th century, which in any way indicate any knowledge about the practice of wet copper production. Little was of higher interests to the early alchemists as the idea of changing or faking metals – especially precious or semi-precious metals – out of base metals. This can already be seen from recipes as old as the so-called Leyden Papyrus X from Egypt, where numerous more or less

[413] Karpenko & Norris (2002), p. 998.

[414] A detailed discussion of these efforts in the context of Arabic, European and partly also Indian sources is provided by Karpenko & Norris (2002), p. 998ff. and will thus not be pursued much further in this place.

efficient recipes for the transmutation of metals are contained, of course not including wet copper.[415]

Fig.37: Phantasy portrait of Basil Valentine from 1717. Source: *Chymische Schriften* published by Samuel Heyle, Hamburg.

The first alchemist source clearly observing the process, though clearly not identifying its essential parts, is contained in Basil Valentine's *Currus Triumphalis Antimonii*. The text reads as obscure as the circumstances of its compilation. Close to nothing is known even about the lifetime of the Benedictine monk, the origins of his knowledge and ideas and the authenticity of his books lay largely in the dark. He is however generally believed to have been from Hessen in Germany and to have written most of his works around 1500 including some older material into them.[416]

415 Leyden Papyrus X / Lagercrantz (1913).

416 For the discussion of the questions around Basil Valentine see e.g. Fritz (1941) or Priesner (1986).

> Datur & alia extractio per aquam causticam sic, Vitriolum & sal commune aequis partibus simul tero, & ex iis perlatus aquam distila, ignem si urgeas ilicies liquorium butyro fuso aut oleum simile.Hunc asserua ad tempus & vsum suum.
> Caput mortum pulverisa & solue in cellâ in aquam qui seorfim collige & filtra per cartam. Exin accipe Antimonium Vngaricum minutissime tritum in vitro fundo plano affunde ei istam aquam, repone in calore vbi si per tempus permanserit ab initio amethysti colorem imitator violacium, quod vbi ad hunc statum reductum est, auge ignem & habebis colorem sapphire pellucidi es hoc sapphirino colore descendid puluis albus affusâ aqua communi intus assumtus idem facit quod extraction vitrioli crudi per sedes & vomitum.
> Solutio in cellâ ex capite mortuo extracta laminas martis tenues in ipsa coctas vere in Venerem mutat experientia teste.[417]

> Another extract is obtained by means of caustic water in the following manner: Take equal parts of vitriol and of common salt; from these distil a water through the side. The product, after violent heat, is a substance like melted butter, or olive oil. Reserve it for use.
> Pulverize the *caput mortuum* very finely, dissolve in water, strain through paper; take Hungarian Antimony, pulverize finely, place in broad-bottomed cucurbit, add to it water, and subject to heat. After remaining there for a certain time, it becomes like an amethyst, of a dark violet ; increase the heat of the fire till the substance becomes blue like a sapphire; from this is precipitated a white powder by the effusion of common water. This powder is an emetic and purgative like the red extract of glass of Antimony. In the first solution made of the caput mortuum, you may subject thin plates of iron to coction, and will then truly transmute Mars into Venus, as experience shows us.[418]

The process describes first the creation of a copper bearing aqueous solution by means of leaching out two different copper bearing substances: Vitriol and *caput mortuum*. The latter term can either be understood as a mineral red pigment made of iron sulphate, which was

[417] Basil Valentine (1646), p. 73f.

[418] Basil Valentine / Kerckringius (1893), p. 135.

used for painting[419] or as an alternative expression for the term "crocus veneris", representing copper oxide.[420] In the first case, this substance would not have been of any use for the reaction but would have possibly been used because the general power to colour things red was ascribed to it. In the second case, the substance would also not really have fulfilled its function but because this substance may have been obtained as a by-product of roasting copper or iron ores, it would have been likely that still some suitable material was contained in it. The addition of antimony is neither necessary, nor helpful for the reaction either, apparently Basil Valentine added antimony into all the recipes described in his *Currus Triumphalis Antimoni* in order to demonstrate the importance of this element, probably because in the symbolic system of planetary metals antimony shares its symbol ♁ with the one of the earth.

When the actual reaction is executed at the end of the passage, its particular symbolic meaning in the context of European Alchemy becomes obvious: Iron is related to the planet Mars. Its planetary symbol ♂ shows a round shield and a spear with an iron head; by doing so carries the attributes of the graeco-roman war god Ares/Mars and represents masculinity. Iron is related to the Venus and its symbol ♀ is deducted from a hand holding a mirror made of copper; this is the attribute of Aphrodite/Venus, the goddess of love and representation of the feminine. Following this Allegory, the transmutation of Iron into Copper represents nothing less than the transmutation of male into female.

419 Harley, R.D. (2001).

420 Liungman, Carl G. (2004).

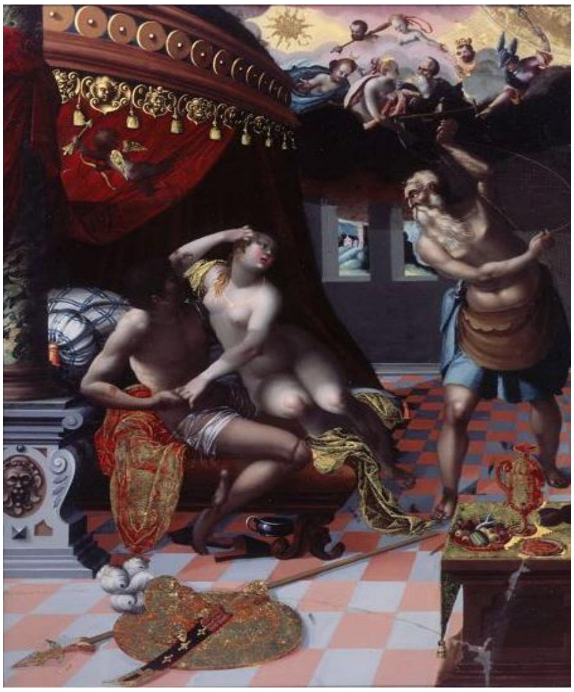

Fig. 38: Venus and Mars are surprised by Vulcanus. Reverse Glass Painting by Hans Conrad Gyger (1631). The iron weaponry on the floor is attributed to Mars, the brass dishes on the table belong to Venus.
Source: Swiss National Museum, Zurich.

The argument that Venus is married to Vulcanus, the god of metallurgy and fire but cheats on him with Mars may be too speculative, to lead to the assumption, that the idea of copper production without fire through precipitation on iron was already present during early European Antiquity. In the 16th century, however it was interestingly popular to display them together in a bath tub. (see Fig. 39 for only one instance). The fact, that Vulcanus catches them with a fishing net is another detail indicating a certain relation to water included in this constellation (see Fig. 38).[421]

[421] There is another interpretation of this story by Isaac Newton, who sees the creation of a copper-iron alloy, which under certain circumstances has a purple net structure on its surface as its alchemist background.

Fig.39: Venus and Mars bathing together. Print by Antonio Fantuzzi (1543)
Source: British Museum, London, Department of Prints and Drawings.

B) Earliest Wet Copper Production Places in Europe

Taking Pliny's and Basil Valentine's text and the other related aspects concerning knowledge about wet copper into consideration, it still remains largely unclear, where, when and how any application of the Process outside of China started.

Slovak Ore Mountains (Slovakia) and Kutná Hora (Czech Republic)

More reliable answers can only be found from the middle of the 16th century onward, when the famous Georgius Agricola mentions the process explicitly in his *De Natura Fossilium*:

> Ferrum quoque alieno inficitur colore. Siquidem aceto & alumine uel atramento sutorio illitum, fit aeri simile: quod mirum uideri non debet. Smolnich, quod oppidum est Carpati montis eiusque partis Vngariae, que quondam Daciae nominabatur, ex puteo extrahitur aqua & in canales triplici ordine locatos infunditur, in quibus posite portiones ferri

> uertuntur in es. Minutum autem ferrum, quod in fine canalium collocatur, talis aqua ita excedit, ut fiat quasi lutum quoddam. Id vero omne postea excoctum in fornacibus fit aes purum bonumque.[422]
>
> Iron also can be tinted an alien color. It can be made the color of copper when covered with acid and *alumen* or *atramentum sutorium*. There is nothing extraordinary about this. At Smolník, a town in the Carpathian mountains in that part of Hungary that was called Dacia at one time, water is taken from a well and poured into canals that are grouped in series of three. Some parts of the iron, which is laid into these canals is turned into copper. Some tiny pieces of iron that are placed at the ends of the canals are passed by the water in such a fashion that they become some kind of mud. After this [mud] is completely dried out, it becomes pure and good copper in the furnaces.[423]

A mistake in the translation of *De Natura Fossilium* into English by Bandy & Bandy[424] has been the reason that basically any notable international publication on the topic of wet copper history including Lung[425] and Golas[426] has located the first appearance of wet copper production at a place which could not be identified any more, a town called "Smolensk" in Hungary (not to be confused with the city of the same name in western Russia). But Agricola's text in its original print from 1546 clearly reads "Smolnich", which more likely seems to be Smolník (Hungarian: Szomolnok; German: Schmöllnitz; mentioned in 1327 as "Semelnech") in the Slovak Ore Mountains (Slovenské rudohorie) mountain range. Smolník has a history of copper and iron production, which reaches back

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422 Agricola (1546), p. 344f.

423 Agricola / Bandy & Bandy, p. 188. with two modifications by the author ("Smolník" instead of "Smolensk", "well" instead of "pit").

424 Bandy & Bandy, p. 188.

425 Lung (1986), p. 125.

426 Golas (2005), p. 385.

at least until 13th century and which is closely related to German settlement in this region during the Middle Ages.[427] As Agricola states, during his time the town belonged to the Kingdom of Hungary and is indeed situated on the territory, which at least during late Antiquity belonged to the Roman province of Dacia. I t can thus be regarded as definite that it is this place, which Agricola is referring to.

The words, which Agricola uses to describe the process are remarkable: Firstly, he uses the exact same terms "acetum" and "alumen" to describe the material applied on top of the iron, as Pliny the Elder did roughly 1500 years before him, although other words like "vitriol" were already in use for a long time. This and the remark that "there is nothing extraordinary about it" lead to the assumption, that Agricola must have known and used the *Naturalis Historia*, being not only an eminent scholar of various natural sciences but also a student of classical Latin literature and language, this is no surprise. It would in fact be surprising, if a process described by no surviving source before him except the *Currus Triumphalis Antimonii* could really already be regarded as commonly known.

While this remark concerns the technology itself as it can be carried out by rubbing or smearing iron pieces with copper sulphates, in the following the execution of the process on a at least somewhat larger scale is described. Apparently Agricola describes a very similar process to the one of copper soaking in China,[428] which solely relied on vitriol water available in the nature and did not involve any leaching process.

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[427] Netíková (2007)

[428] See chapter IV of this thesis.

What is special is that he mentions that “Parts of the iron laid into these canals are turned into copper”, while “Some tiny pieces of iron that are placed at the ends of the canals are passed by the water in such a fashion that they become some kind of mud”. This could refer to a practice, that the stronger copper-bearing water in the upper parts of the gutters was actually used to coat finished iron objects with a copper surface, making them appear like directly turned into copper, while at the end parts the low-quality water was used to slowly erode very small iron chips completely and turn them into the copper mud described before[429], which was then dried and smelted in the furnace.

Another passage, which is 24 years younger, presumably refers to the same mining region in Slovakia, then Hungary as well as to another one, the important mining town of Kuttenberg (Czech: Kutná Hora), which lays several hundred Kilometers west of it in what today is the Czech Republic.

> Dann die pauren in Ungeren so sie ein eysen sein zeit in Zypfferbrunnen legen / so wirts zu einem Roßt gefressen / welcher durch den schmeltzoffen gelassen von stundan ist ein rein Venus /unn nimmermehr zu eysen reduciert wirt / Deßglichen auch auff dem Kuttenberg giessen sie ein kyßlaugen / in welchem flux eysen zu gutem bestendigen Venus wirt / hochgradiert unnd milter underen hammer weder dz natürlich Venus / Dieser ding sein noch mehr / unnd schlechten leuten mehr dann den Sophisten bekannt welche ein specien metalli in das andere transmutieren.[430]

> When the peasants in Hungary cast iron at the proper season into a copper well, it is eaten into rust, and when this is liquefied in a furnace, it soon exists as pure Venus, and never more returns to iron. Similarly, on the Kuttenberg mountain, they obtain a lixivium of chalkopyrites; in

[429] see chapter IV.3 of this thesis.

[430] Paracelsus (1570) chapter 7, p. 26.

> its flow iron is forthwith turned into a good changeless Venus of a high grade and more malleable than the one produced by Nature. These things, and more like them, are known to simple men rather than to sophists, namely, those which turn one appearance of a metal into another.[431]

What Paracelsus describes in this passage for the situation in Hungary is basically identical with the description by Agricola. He, however, mentions that the process is carried out by farmers ("pauren") rather than by miners, a remark which might in fact indicate that wet copper production was, though probably not exclusively, but also carried out by villagers who were otherwise not involved with mining as a side-line occupation.

Similar to the Agricola text, the most common (if not the only) English translation by Waite contains a severe mistake with a misleading influence on secondary research as well. He interprets the Word "Zypfferbrunnen" as a place name and calls it "Zifferbrunnen", while it is in fact nothing else than a "copper well" and thus a natural source of vitriol water.[432] Besides, he misreads "kyßlauge" into "a lixivium of marcasites", which would be a ferrous sulphate. In fact the word refers to "a lixivium of chalcopyrites", which are also called "Kupferkies" in German. "Kyßlauge" is thus nothing else than copper sulphate bearing water obtained by leaching.[433] Accordingly, Paracelsus's description of wet copper production in Kutná Hora is the first example for the application of the copper leaching process

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[431] Paracelsus / Waite, p. 28 with modifications by the author (e.g. "Copper well" instead of "a so-called 'Zifferbrunnen'", "chalkopyrites instead of "marcasites" etc.).

[432] For the appearance of the word „Zipfferbrunn" in this context see e.g. Jablonski (1748), p. 528.

[433] Jablonski (1748), p.528.

outside of China. It seems that the obtained lixivium was purer and naturally of a higher copper content than the natural vitriol water and thus able to produce copper of a particularly high quality.

In his final remark he most interestingly indicates not only that the process was carried out by peasants, but also, that the knowledge about it was kept by the simple people ("schlechten leuten") rather than by educated experts and the very last by alchemists "which turn one appearance of a metal into another". This estimation from the feather of Paracelsus is believable because he truly was a person who knew both sides. Before he started his outstanding academic career, he had worked as a travelling healer and journeyman miner for twelve years[434] and had during this time in fact travelled through the mining regions of Hungary and other countries. It of course also fits into his attitudes displayed during later times, when he supported the peasants' side in the German Peasants' War and polemised against the so-called "Sophists" in many of his writings.[435]

Although based on these sources it is in fact possible to estimate conservatively, that wet copper was produced in Europe the latest from the first half of the 16th century onward, none of them actually mentions any time of invention or discovery. Such a remark can only be found in a much later source, which, however, refers to the Slovakian Ore Mountains as well, in particular to the town of Herrengrund (Slovak: Špania Dolina) near Neusohl (Slovak: Banská Bystrica). This place was famous for its very delicate metal dishes produced especially from wet copper:

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434 Conner (2005), p.306.

435 See e.g. Paracelsus (1570) chapter 1, p. 9.

"Dieser Ort [Herrengrund] ist wegen seines guten und ergiebigen Bergwerkes, hauptsächlich aber des so genannten Cementkupfers wegen merkwürdig, welches im Jahre 1605 entdecket worden. Es befinden sich hier über zwanzig Kammern, in welchen dieses Wasser theils herabträuft, theils aus der Erde quillt, und durch hölzerne Röhren abgeleitet wird. Das Eisen, welches man in dieses Wasser legt, wird nicht verwandelt, sondern ausgefressen, und die in dem Wasser befindlichen Kupfertheilchen werden in dasselbe niedergelegt. Diese Veränderung geschieht in zwey, drey, oder mehr Wochen, nachdem ein kleineres, oder größeres Stück Eisen dazu gebraucht wird. Wenn es aber zu lang in dem Wasser liegt, so zerfällt es in ein Kupferpulver. - Aus diesem so genannten Cementkupfer werden allerhand Geschirre, Bächer, Tabaksdosen, und dergleichen mehr gearbeitet, auf die man verschiedene Verse eingräbt, und als eine Seltenheit auch außerhalb des Landes verschicket".[436]

This place is mainly famous because of its good and abundant mines, but especially because of its so-called cement copper, which was discovered in 1605. There are more than twenty chambers, where this water either flows down or gushes out of the earth and is diverted through wooden pipes. If one puts iron into this water, it is not transmuted but eroded and the tiny pieces of copper, which are in the water, are laid down on top of it (i.e. precipitate). This transformation takes place within two, three or more weeks depending on whether a smaller or larger piece of iron is used therefore. If it, however, lays in the water for too long, if will decompose into a copper powder. From this so-called cement copper all kinds of dishes, cups, snuff boxes and the like are crafted, on which different verses are engraved and which as a rarity are also sold abroad.

The verses, the author is referring to bear very impressively witness to the positive to admiring attitudes, which must have dominated the feelings of Europeans towards wet copper during the earlier years of its existence.

[436] Windisch (1780-1790), p. 190.

Fig 40: Front and back view of an 18th century "Tummler" drinking cup from Herrengrund, gilded cement copper. The engraving reads: "Hart eisen ich vor war, ein wasser hell un klar, macht mich in wenig stund, zu kupfer in herrn grund."
Source: http://www.hermann-historica-archiv.de/auktion/hhm56.pl?f=NR&c=73450&t=temartic_P_D&db=kat56_p.txt (visited on January 31, 2014)

One short poem shows at first the difference between the hard work necessary for the conventional production of iron from ores obtains through underground mining and the much easier transformation in the water through the wet copper method. Besides, it is clarified, that scrap iron rather than virgin iron must have been used for the process, only iron "was of no use any more":

> "Die Ankunft mein ist Eisen hart / im Bergwerck must ich graben starck / Da man mich nicht mehr brauchen kunt / warf man mich in den Zimendt Grunt / Das Wasser zu Kupfer mich demperiert / Bin worden ein schalen mit goldt geziert.[437]
>
> I arrived as hard iron / and had to be dug from a mine forcefully / When I was of no use any more / I was thrown onto the ground of the cementation gutter / The water has heated me up to become copper / Now I am a bowl adorned with gold.

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[437] Inscription on a wine tasting Bowl from 17th century. Kinsky Kunst Auktionen, Vienna, Art. No. 761, 28/09/2010-05/12/2010.

Much more detailed than this is the inscription on a very delicately worked snuff box, which shows the high appreciation of copper in comparison to iron and also picks up the Mars-Venus motive again:

> Als ich vor schwartzes Eysen war / Verachtet man mich gantz und gar / Seht, wie hält man mich jetzt rar. […] Aus schwartzen Eysen ich zu Kupffer bin gebracht, / darum der Künstler mich zu Tobacks Dotz gemacht, / Mit Gold bin ich gezieret fein, / Drum grosse Herren mir günstig seyn. […] Viel Wasser find man ja, Ost, Syden, Vesten, Norden, / Doch ist von keiner Krafft Ein solchs gefunden worden, / Als nur im Ungerlandt, Welchs Mars zur Venus macht, / Drum es bey jedem Stand Wird hoch und werth geacht.[438]

> When I was black iron before / I was so despised by people / Look how much one appreciates me now! […] From black iron I was turned into copper / therefore an artist has made me into a snuff box / I am delicately adorned with gold / may great lords look at me benevolently. […] Much water can be found in East, South, West and North / But never one of such a power has been found / As just in Hungary, which turns Mars into Venus / Therefore it shall be highly valued everywhere.

Some engravings, are also very short and less loaded with meaning. The vast majority of them however include allusions to the production of their material through the wet copper method.

> Eisen bin ich gewesen, / Ziment Wasser zu Kupfer hat mich gefressen, / bin geworden vergult. / Fein schmect wohl aus mir der kuehle Wein.[439]

> I was iron / cement water has eaten me into copper / I was gilded / tasty is the cool wine you drink from me.

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438 Inscription on a snuff box from 18th century. Kinsky Kunst Auktionen, Vienna, Art. No. 758, 28/09/2010-05/12/2010.

439 Inscription on a wine tasting Bowl from 17th century. Kinsky Kunst Auktionen, Vienna, Art. No. 759, 28/09/2010-05/12/2010.

Other Regions of Central and Northern Europe

Another region, which apparently began very early to make use of the wet copper method, were the Hartz mountains in Northern Germany. In his "Gründlicher Unterricht von Hüttenwerken" (Detailed Report on Smelters), Christoph Andreas Schlüter mentions, that during the resumption of copper mining activities at the Rammelsberg mines, the method was already well known and experimented with. The latest from 1607 onward it was executed on a regular base.[440] In the following 200 years the process is increasingly mentioned all over Europe, e.g. in Sweden, Norway, Venice[441] or Wales.[442] This spread, however enters entirely new historical and technological contexts and was of course also closely related with the early development of modern science. In spite of its very interesting character, it will not be treated here in detail, but only touched upon with regard to aspects of knowledge transfer.

Río Tinto (Spain)

Another mining region, which could be of greatest importance for the question, when and where wet copper was first produced outside of China, is the one around the Río Tinto ("coloured river") in Andalusia. According to three secondary instances, wet copper production was carried out by the Arabs in this region. Unfortunately, none of the three

[440] Schlüter (1738), p. 460ff.

[441] Golas (2005), p. 385.

[442] Lentin (1800), p. 70f.

works[443] cites its source and none provides any further detail information, so that this case needs to remain doubtful.

If one would assume, that these statements are true, this would mean that copper precipitation outside of China began the very latest in 1248, the year, in which Ferdinand III. of Castile conquered Seville and the surrounding regions including the Rio Tinto mines from the Arabs. So far, however, no further sources could be traced to confirm this.

Fig. 41: Old ponds for wet copper productions at the Parys mountain mines, Island of Anglesey, Northern Wales. Source: Photography by David John Hale.

443 Read (1937), p.3.; Bromehead (1956), p.11; Hassan & Hill (1986), p.249.

C) Knowledge Transfer or Re-invention(s)?

If one considers 13th century Andalusia and 16th century Hungary as possible places of origin for wet copper production in Europe, one fact is striking: Both regions witnessed intensive contacts, warfare, occupation and reconquest with Muslim counterparts during the respective time. In Andalusia, this was as mentioned above, the so-called "Reconquista", the wars related to the re-Christianisation of Spain after more than 550 years of Muslim rule. The Ottoman-Hungarian wars endured with interruptions for more than 150 years and culminated in the campaigns of the Sultans Bayezid II. (1481-1512) and Suleiman the Magnificent (1520-1566) leading to the siege of Vienna in 1529 and eventually to the ottoman occupation of large parts of present-day Hungary and Slovakia.

These historical situations, which must have made the respective mining regions necessarily to places of repeated and enduring encounter between two bodies of knowledge, which usually due to special, political, linguistic and cultural barriers may usually have been somewhat, though of course not entirely, separated from each other. This and the above mentioned indications by Read, Bromehead and Hassan & Hill may allow the assumption that ideas of wet copper methods may have existed and circulated within the abode of Islam, though no explicit written records of them survive. If at all, however, one aspect of the *Mabāhij al-fikar wa manāhij al-ʻibar* ("The joys of ideas and the methods of giving lessons") by the Cairene Muḥammad ibn Ibrāhīm ibn Yaḥya al-Waṭwāṭ (1234-1318)[444] may be taken into consideration. Other than earlier Arabic or Persian

[444] al-Waṭwāṭ / Sezgin & Amawi (1990).

works, he does not categorise vitriols as salts, like for example Ibn as-Sina did, but subsumes them under a new category called “stones whose nature changes that of other stones”.[445]

If one continues this thought, it can be at least considered possible that the knowledge which arrived in Spain during the 13th century could have had its origin in China. During the early time of the Mongol conquests of Eurasia, which had begun in 1206, in China knowledge about wet copper was very widespread (the *Daye fu* was written in 1210) and numerous possible transmitters, who may have had contact with the technology in China may have travelled with the Mongol armies into the lands of Islam. Of course in the absence of any explicit evidences, this constructed course of events remains highly speculative. Nonetheless it should be taken into consideration that it was ironically during the siege of Seville in 1248, when gunpowder and cannons – clearly a Chinese invention - were first used by the Arab Almohads on European ground and thus introduced to the Christian West.[446]

While this scenario remains possible, it may not be the only thinkable and probably also not the most likely one. Two important aspects need to be taken into consideration:

Firstly, as the above cited passage by Paracelsus[447] has already indicated, at least in Hungary wet copper production was to its biggest part not the profession of educated experts or of alchemists writing books which would be copied and distributed, but rather of commoners learning

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[445] Karpenko & Norris (2002), p. 999f.

[446] Manucy (1994), p. 97.

[447] Paracelsus (1570), chapter 7, p. 26.

from their neighbours or passing knowledge on to the next generation. This character as so-called "tacit knowledge" makes it difficult to retrace its path reliably and reduces its chances to spread fast over a larger space or among a large population. Nonetheless, together with an actual migration of the knowledge keepers, a transfer can still be imagined.

Secondly, the incidental discovery of the phenomenon alone is not very unlikely: Around most copper mines, natural vitriol waters appear in one form or another. If one also takes the fact into account that the majority of striking tools for mining is made of iron, it does not need much imaginative energy to create situations leading to such a discovery. Even in China, where through the existence of the *Jintong yaolüe* and its prefaces a strong, believable narrative for the invention of the method was available, for instance the *Qingbo zazhi* related such a story:

> 信州鉛山，膽水自山下注，勢若瀑布，用以浸銅，鑄冶是賴。雖乾溢係夫旱潦，大抵盛於春夏，微於秋冬。古傳一人至水濱，遺匙鑰，翌旦得之，已成銅矣。[448]

> In the Yanshan district of Xinzhou, there used to be a stream of vitriol water flowing down out of the mountains like waterfalls. It was utilised for copper soaking, the smelters relied on it. The water flow in the rivulets was due to the weather, flowing more abundantly in spring and summer, less in autumn and winter. It is said that in the old times a man came to the riverside and lost his key there. When he recovered them on the following morning, they had turned into copper.[449]

Another quite impressive example of the volatile character of knowledge related to wet copper can be found in a letter written by the German chemist and salt works inspector Augustin Gottfried Ludwig Lentin (1764-

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[448] QBZZ chapter 12, p. 502f.

[449] Translation by Lung (1986), p. 117, slight changes by the author.

1823). During his lifetime, as today can easily be retraced from various sources, not only in Germany but all over Europe copper was produced with hydrometallurgical means. Lentin is aware, that in the past the process had been in use in the Hartz mountains years ago but it still requires him to travel to Wales to find the words:

> Heute, mein werther Freund, will ich es versuchen, Ihnen einen Prozess zu beschreiben, der, so viel ich weiss, nur allein in Anglesea üblich ist, der aber, wie Sie selbst gestehen werden, auch auf andern Kupferwerken angewendet zu werden verdient, weil er nicht nur den langwierigsten aller Hüttenprozesse sehr abkürzt, sondern auch zugleich ein vorzüglich gutes Kupfer liefert.[450]

> Today, my dear friend, I want to try to describe to you a process, which, as far as I know, is only and alone in Anglesea in use, but which, as you might like to admit, deserves to be applied at other copper smelters as well, because he not only reduces the time necessary for the lengthiest of all smelting processes remarkably, but also yields outstandingly good copper.

If even at least one of these surely specialized and educated correspondence partners was to that extent unaware of the situation of wet copper production in Europe, it can be imagined, that in less literate circles knowledge about methods applied somewhere else beyond the borders may have been even slimmer.

[450] Lentin (1800), p. 68.

Fig.42: Copper precipitation plant in Butte, Montana at the beginning of the 20th century.

It is thus not astonishing, that when by the end of the 19th (sic!) century wet copper production began in Butte, Montana in the United States, and those facilities were built which would develop into the largest and worldwide most productive ones in history, people thought that the technology had actually been discovered and invented in Butte. A guidebook to the city from 1937 still confirms this vividly and tells the related story:

> A German, Frederick Mueller, who came to Butte in 1889, discovered the precipitation process and held a lease on the mine overflow for three years. […] Being of a scientific mind an interested in chemistry, his attention was attracted by the green- coloured streams of water from the mines passing his house, which were obviously of a heavy copper content. Mueller did much puttering and experimenting - which his wife considered a foolish obsession. Not so his daughter Lucy, however, who was as much interested as her parent and became his eager ally and constant companion in his experimenting. They filled some holes in their yard with the green water, put a lot of tin cans into these holes and awaited patiently the result.

> The tin can idea came to Mueller from his frequent visits to the mines, he […] found that the copper water was so strongly impregnated acid, that all the pipes and machinery were ruined by the action of the acids in the water. The machinery was only saved by lining the columns with lead. With this information, the idea with the tin cans was born. After many daily visits to his yard holes, Mueller finally found the tin cans had disappeared. In their place was a soft brown dirt. […] Filling three cracker boxes with his "mud", he took them to the smelter, where he received $45 for his dirt.[451]

It is not clear, if Mueller himself had possessed knowledge of the process before and just made people think that it is his invention or if he actually found things out by himself. It is also hard to imagine, that in a thriving 1930s copper mining centre like Butte no geologist knew better than this.

Fig. 43: Chinese immigrants smoking in a bunkhouse in Butte, Montana around 1880. Many thanks to Ulrich Theobald for providing me with this picture. Source: Photograph by E.P. Ferte.

451 Anon. (1937), chapter "Industry" (no page numbers).

The entry in the guidebook still shows that the story of Frederick Mueller was believable to the public of his city and country. The numerous Chinese immigrants, who were mainly working as miners in Butte,[452] however, did not seem to be involved into the process of introducing wet copper production.

Although the originality of Frederick Mueller's "invention" in Butte may be doubted, for the distribution of knowledge about wet copper production, similarly to other fields of knowledge concerning mining and metallurgy, it seems that German miners and mining experts have played a crucial role. Not only, as presented above with the texts by Basil Valentine and Paracelsus, were the first written sources on this topic compiled by Germans, also close to all the early sites of wet copper production were related to the migration of German miners, mainly from Saxony. This holds true for the mining region in the Slovak Ore Mountains, where for instance the mining towns of Neusohl (Banská Bystrica) or Schemnitz (Banská Štiavnica) were largely settled by German immigrant miners; the same was true for Kuttenberg (Kutná Hora).[453] While the locations within the Hartz Mountains like the Rammelsberg near Goslar are in Germany anyway, close connections between Germany and the later areas of application can be retraced as well. In 1551, 200 German miners opened the silver-lead mines of Guadalcanal in Spain, only about 50 kilometers north-east of the Río Tinto, and in 1623 the Kongsberg mines in Norway.[454] Connections to the later flourishing production sites on the British Isles are also not hard to trace: Already in

452 Osbon (2011), p. 6.

453 Sedlar (2011, p. 115.

454 Bromehead (1956), p. 11.

1529 the English Crown invited German mining experts to develop mines in Cornwall and Ireland.[455] The already mentioned compendium "Gründlicher Unterricht von Hüttenwerken" (Detailed Report on Smelters) by Christoph Andreas Schlüter, which contains comprehensive descriptions about wet copper production, was dedicated and handed over to King George II. of England, where it must have contributed remarkably to the great development especially of the copper industry in the following decades.

The further spread of hydrometallurgical technology in newer times, into other world regions, especially into Asia will be discussed below.[456]

2) Wet Copper in Modern China

After centuries, during which sources are scarce to non-existent,[457] it can be observed that during the 20th century, wet copper production with methods similar to the ones described has been existing again in China and is existing until today in several places.

A) Sites Producing Wet Copper

Wet copper production can be carried out on a very small scale as a side occupation by anyone living close to any place where vitriol water appears in the nature or can be leached from earth or ore *in situ*. Even

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455 McNeil (2002), p. 81.

456 see chapter IX 2b of this thesis.

457 see chapter VII.5 of this thesis.

larger facilities can be established entirely on a very local level, because not much investment is necessary. This makes it impossible to gain any close to complete overview over all places where wet copper production is carried out at present. The places listed in the following can thus only be seen as examples but may not represent the entire picture.

Fig. 44: Very small private wet copper production facilities in Dexing (left) and Yongping (right). Source: Photos taken by the author in 2011 and 2012.

Jinguashi 金瓜石 (Taiwan)

This place in Taiwan is mainly famous for its rich gold mines, but due to the presence of great amounts of copper sulphate bearing earth and ore produces a fairly steady flow of vitriol water. Golas[458] and Lung[459] report that between 1944[460] and 1982, Jinguashi produced 29 000 tons of wet copper which would make it the largest producer of copper with this method in China throughout history. Lung, who was the director of this Facility in the 1970s and 80s, describes the applied process as almost unmodified from the one in use during the Song period with the only exception that scrap iron was used instead of virgin iron.[461] As can be said for sure after including textual evidence from the *Daye fu* and other sources, this was also not a difference but was already carried out the same way then.[462]

It is interesting to note, that at Jinguashi apparently for many years wet copper production with traditional methods based on natural vitriol water was combined with electrometallurgical wet copper production of copper from ores.[463]

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458 Golas (1999), p. 384.

459 Lung (1986), p. 124.

460 The origins of wet copper production in Taiwan are discussed in chapter IX.2b of this thesis.

461 Lung (1986), p. 124.

462 See chapter IV.5 of this thesis.

463 The Taiwan Digital Archives hold a short documentary filmclip from 1975 presenting the coexistence of the two methods, see http://catalog.digitalarchives.tw/item/00/31/9c/bb.html (visited on 02/10/2014).

Fig. 45: The wet copper production ponds of Jinguashi before their destruction by a taifun in 1987.
Source: http://museum02.digitalarchives.tw/teldap/2010/Chinkuashih/140.124.55.132/imgd574.jpg?type=photos&fid=1110270753_813.jpg.

Fig 46: Presentation of wet copper production at the present-day Jinguashi Gold Ecological Park (*Huangjin bowuyuan* 黃金博物院). The building at the top right is the newly restored office of copper precipitation. (*Shendiantong bangongshi* 沈澱銅辦公室).
Source: http://erica032.pixnet.net/blog/post/24531329-散步在黃金博物園區.

From 1982 onward, however, copper mining activities declined and also the production of wet copper was successively given up. In 1987 a taifun destroyed all the gutters, which were directly built at the seaside (see Fig. 45). Because by then production had already become uneconomic, they were never rebuilt. Today a large modern mining theme park presents the metal production technologies in Jinguashi's pas to the interested public. The exhibition also includes one rebuilt gutter for wet copper production and the administration office for copper precipitation has been rebuilt after it had fallen into decay over the last decades (see Fig. 46).

Yongping 永平 (Jiangxi)

Golas mentions, that as a part of the policies related to the "Great Leap Forward" in the 1950s, the government of the Peoples' Republic of China promoted the production of wet copper in several areas.[464] It is, however at present not possible to trace any existing wet copper production facilities back to this time period.

There are, however, several copper production facilities around the Yongping copper mine 永平銅廠 in the Yanshan 鉛山 district of Shangrao 上饒 city in Jiangxi province. These facilities make use of rain water leaching out heaps of vitriol earth and poorer sulphate ores at the edges of the abandoned parts of the large open pit mine. The author has visited two of these production sites in the years 2011 and 2012 and recorded most of the following information from interviews with the workers and leaseholders of the respective facilities as well as with local cadres and residents.

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464 Golas (1999), p.384, Guo Zhengyi (1983), p. 61.

The scale, on which wet copper production is carried out at these sites, is much smaller than at Jinguashi and also much smaller than it must have been during the Song period. The methods, however, are into detail identical to the ones applied then, the only apparent differences being the gutters, which are constructed with the help of concrete and the scrap iron, which is chipped into helical shapes by a modern recycling macerator. [465]

The process is referred to as "sponge copper" (*Haimian tong* 海綿銅) in this region, a term which is derived from the respective English term "sponge copper" describing a process including the leaching of ores and the heating of the leachate, which was first applied in 1837 and which is not the same with the one in use around Yongping.[466] It is however possible, that the term relates to the helical shape of the iron, which reminds of a steel wool sponge.

[465] More details and more pictures about the actual execution of the process at these two facilities, see chap. IV of this thesis.

[466] Lung (1986), p. 124.

Fig. 47: Overview over the Jiuhaoba 九號壩 wet copper production facilities near Yongping. Source: Photo taken by the author in 2011.

Fig. 48: Colour change between the water before and after running through the gutters at Jiuhaoba 九號壩. Source: Photo taken by the author in 2011.

Fig. 49: Workers washing scrap iron at Jiuhaoba 九號壩.
Source: Photo taken by the author in 2011.

Fig. 50: Wet copper production facilities at Shihaoba 十號壩 near Yongping. Gutters with waste water pipe (left) and scrap iron storage (right).
Source: Photos taken by the author in 2011.

The two establishments lay in a distance of few kilometres along the edge of the former open pit mine above the villages Jiuhaoba 九號壩 (“[mine] heap number nine”) and Shihaoba 十號壩 (“[mine] heap number ten”). They are operated by lease holding families, which lease the right to use the vitriol water from the local government of Yongping. Every production site employs another five to ten workers, a number which may vary due to seasonal differences in precipitation. While at Jiuhaoba sufficient amounts of water run down the hill naturally and can be controlled by retaining it with a small stone dam, at Shihaoba, vitriol waters are gathered from several directions with pipes. The scrap iron is delivered to both facilities by truck from a recycling plant in Guangdong and the resulting “copper mud” (*tongni* 銅泥) is picked up and delivered to a smelter in the neighbouring city of Guixi 貴溪 (the name interestingly translates literally as “precious rivulet”), where it is dried, processed, finished and marketed by the Jiangxi Copper Company (Jiangxi Tongye 江西銅業), China’s largest copper producer.

The existence of a facility so similar to the ones of the song period posed a great chance to analyse and quantify the process exactly as it was carried out there. Therefore, three water samples were taken, one before the vitriol water got in touch with the scrap iron, one after it had flown through the first line of gutters and one at the end, when it had passed the entire facility and flowed away as waste water. Considering the great variety possible in the copper content of such waters, the analysis may provide an interesting picture about the efficiency of the method:

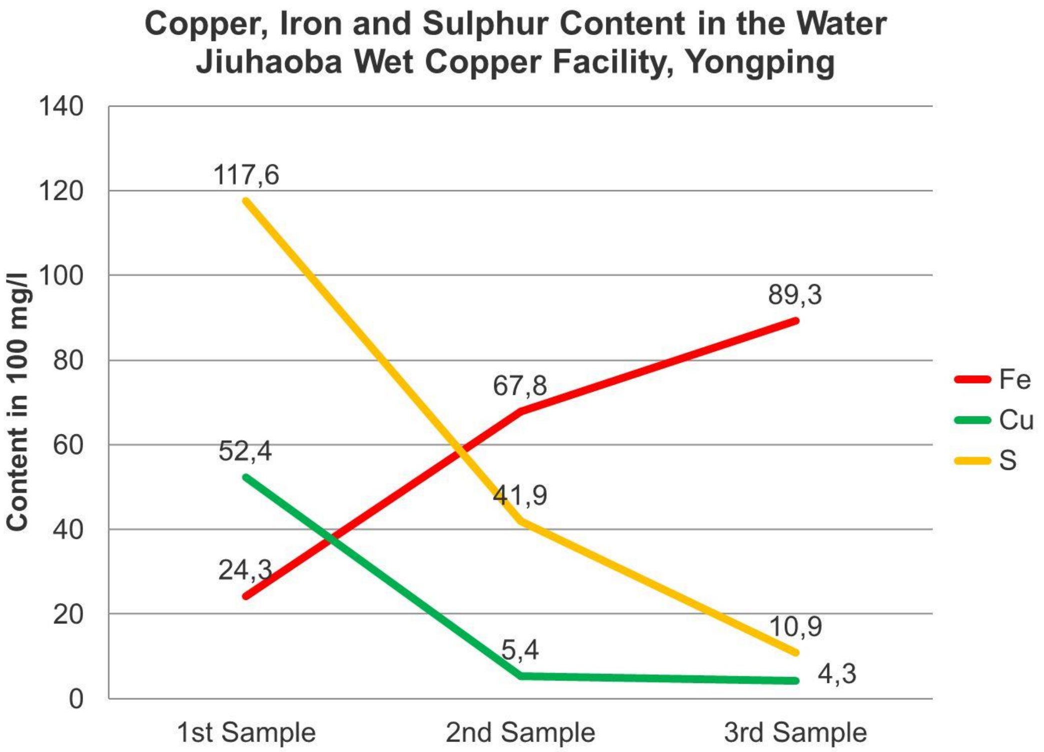

Chart 5: Results of water analyses at Jiuhaoba 九號壩. Iron, copper and sulphur contents before contact between water and iron (1st sample), after first gutter (2nd sample) and when leaving the last gutter (3rd sample).
Source: Graphics by the author.

Apparently, under the natural conditions at Jiuhaoba, the replacement reaction can take place not only very fast but also fairly complete. Already after the first gutter, almost 90 per cent of the copper contained in the vitriol water have precipitated on the iron, after the last gutter it is about 92%. From every litre of water running through the gutters, ca. 48 mg of pure copper can be obtained. What is remarkable is, that not only the copper content of the water declines, but even more the sulphur content. After having been in contact with the iron, it declines by 106.7 mg/l. This leads to the assumption, that the obtained copper mud must be very rich in sulphur as well and thus surely require another roasting process before its ultimate refinement.[467] That the increase of iron in the water exceeds the decrease of copper by ca. 17 mg/l may be explained by the phenomenon, that iron does not only get dissolved into the water by replacement through copper but also through genuine rust. Of course it also needs to be noted, that the water already contains a remarkable amount of iron when it arrives at the facility, this should be due to the composition of the leached out minerals at the Yongping mine, which in the past has been exploited as an iron mine as well.

As to the question of the origins of these and other copper production facilities in the vicinity of the Yongping copper mine, reliable evidence is scarce. According to local residents of the Jiuhaoba village, the facility at Jiuhaoba was planned and set up by a certain Xie Xueguang 謝雪光. The author was fortunately able to meet with Xie who confirmed this and remembered that the respective production site was established in the late eighties, while before wet copper was already produced on a smaller, less regular scale. Small gutters were directly dug into the ground and faced

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467 For a more detailed discussion of smelting technology, see chap. IV.7 of this thesis.

with plastic foil. These small, probably only seasonally operating sites were sometimes operated by the wives of the miners working in the open pit mine. Xie, however remembered, that these activities also only existed for several years, during his childhood and youth before the 1970s he had not witnessed anything the like. A younger village resident, however, remembered that in the 1980s as a child he and his friends soaked iron objects in vitriol water and watched them being coated by copper mud or being completely dissolved for fun.

B) Chinese Tradition or Western Learning?

Considering the fact that apparently in modern times wet copper production on a larger scale has found its way back to China, to the mainland as well as to Taiwan, the question suggests itself, where the knowledge originated, which was applied, when the facilities introduced above were first opened. As has already been mentioned, the history of the facilities around Yanshan cannot be traced further back than several decades, it can at most be assumed, that the efforts to establish wet copper production during the time of the "Great Leap Forward" may have included the Yongping copper mine as well. As for the situation in Jinguashi, Lung[468] and Golas[469] concerning the beginning of wet copper production only mention the year 1944.

[468] Lung (1986), p. 124.

[469] Golas (1999), p.384.

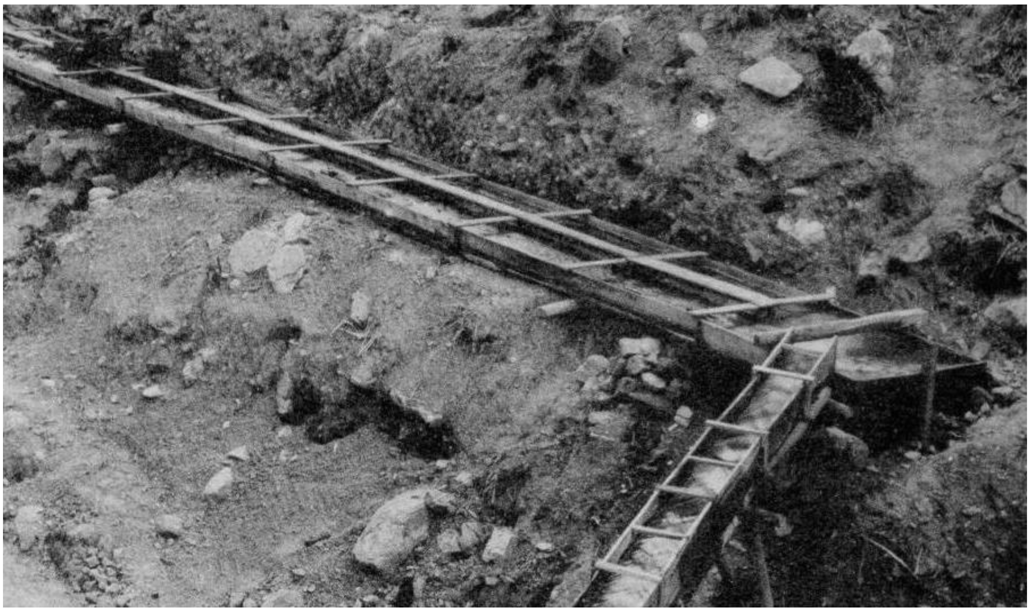

Fig. 51: A wet copper production canal at Jinguashi under Japanese administration in 1914. Detail of a photo from the collection “Photographs from the Jinguashi Ore Mountain” (*Kinkaseki Kōzan Shashinjō* 金瓜石礦山寫真帖) by Kinukawa Takeshi 絹川健吉. Source: National Taiwan University Library.

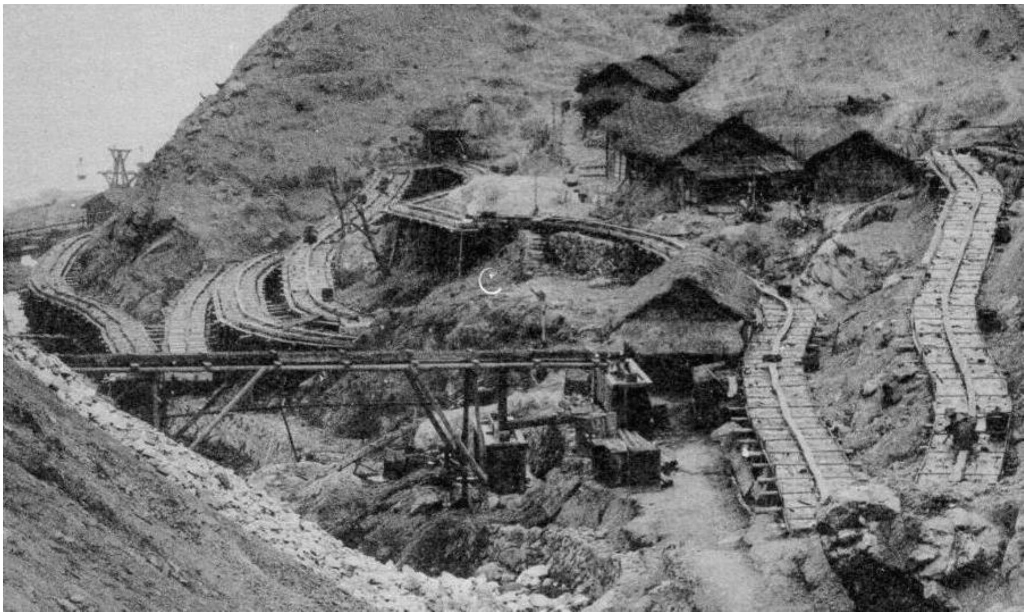

Fig. 52: Wet copper production facilities at Jinguashi under Japanese administration in 1914. Detail of a photo from the collection “Photographs from the Jinguashi Ore Mountain” (*Kinkaseki Kōzan Shashinjō* 金瓜石礦山寫真帖) by Kinukawa Takeshi 絹川健吉. Source: National Taiwan University Library.

True is in fact, that wet copper production, as Lung states, under the direction of the Taiwan Metal Mining company began in 1944. The Jinguashi mines, however, were already exploited during the time of the Japanese occupation in Taiwan, beginning in 1905, when copper deposits were discovered at the place which was before only used as a gold mine.

Henceforth many Japanese miners and craftsmen were employed to set up the facilities.[470] Although it is not entirely clear, from which year on the wet copper works went into operation, a photo album compiled by Kinukawa Takeshi 絹川健吉 shows already completely established facilities, which were apparently made of wood (see Fig. 51 and 52) but in so far showed a similar design similar to the later gutters (see Fig. 45) as they were also constructed with a walking path in the middle above the water level.

Since by the end of the 20th century, different methods of wet copper production were already carried out at several Japanese copper mines like the ones in Besshi 別子, Karuizawa 軽井沢 or Kusakura 草倉,[471] it seems likely to assume that the Technology applied at the Jinguashi mine may have originated from Japan as well. One additional indicator for this assumption is the fact, that in Japan and in Taiwan the process is written as *Shendian tong* 沈澱銅 or respectively *Chinden dō*, while this term is completely unused in Mainland China.

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470 This information originates from the well-informed weblog of Tony Huang, apparently a resident of Jinguashi basing his information on documentation in the modern museum.
Source: http://www.tonyhuang39.com/tony0754/tony0754.html
(visited 02/10/2014).

471 Wada Tsunashiro (1893), p. 111, 197, 215 and 243.

In Japan, However, no mention of wet copper production can be found pointing at an existence of any large-scale methods before 1875, when first attempts were undertaken at the Besshi mine on the Island of Shikoku.[472]

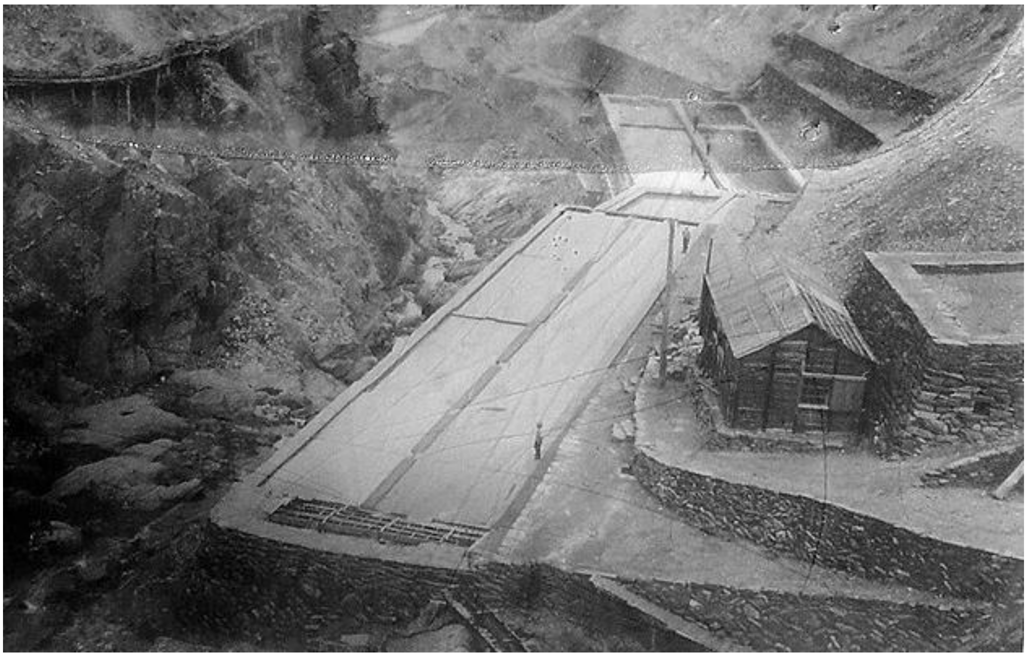

Fig. 53: Basins for wet copper production at the Besshi mine in Shikoku, where wet copper production was first initiated in 1875.
Source: http://outdoor.geocities.jp/ksjjr840/tindenike.3.html
(visited 02/10/2014).

The introduction of wet copper production in Besshi thus exactly falls together with the ambitious attempts of the Meiji government, to modernize its mining industries with the help of foreign experts. The Besshi mine first received foreign advice and instruction in 1871 by the French mining engineer Jean Francisque Coignet (1835-1902) and three years later, in 1874 employed Louis Larroque (1836-1883), who was French as well, as a resident advisor for two years.[473] Only two years after he left,

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[472] Wada Tsunashiro (1893), p 173.

[473] Yoshiki Fumio (1980), p. 24.

the mine began with the construction of firmly installed precipitation basins and another two years later, wet copper production was carried out on a regular base.[474]

While this circumstances of initiation for wet copper production in Japan as well as its beginning under Japanese occupation in Taiwan make it very likely, that the technology applied in these two regions of East Asia was in fact imported from Europe. This does, however, not allow any determinate conclusions for the situation in Mainland China. As has already been stated above, no clear mention of wet copper production can be found in Mainland China in the 20th century before the foundation of the People's Republic. Because of the naturally restricted contacts between Taiwan and Japan on the one side and the People's Republic on the other, it cannot be estimated, where the applied knowledge originated from. Basically, three main possibilities remain:

1. Knowledge on wet copper production persisted in its traditional form in the respective mining regions without leaving any written traces over long periods of time. When new ways were searched to increase metal production in the 1950s, the method was reactivated an applied.
2. Knowledge on wet copper production was transferred either from Taiwan or Japan during the Republican Period, probably in the context of the Sino-Japanese War, when e.g. the copper mining regions of Jiangxi were occupied as well.

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[474] Information obtained from a history of the Besshi mines online, source: http://www2.dokidoki.ne.jp/tomura/douzan.htm (visited 02/10/2014).

3. Knowledge on wet copper production was transferred during the time of the early People's Republic from the West, probably by way over the Soviet Union.

C) Conflicts about Vitriol Water: A Case from Gangzhoucun

At present, wet copper production with traditional methods in China is not carried out anywhere on a scale larger than already described in the preceding chapters. This, however, does apparently not meat, that not many people's livelihood is depending on it and that not much profit can be obtained through it. While during most of the time small scale wet copper production only took place rather unnoticed in several few, locally confined places, in 2012 in the village of Gangzhoucun 港洲村 a conflict over vitriol water resources broke out, which reached a little wider attention. Because this conflict can vividly illustrate many aspects of wet copper production in modern China as well as the relation between private and state actors in this field, it is shortly introduced here:[475]

When in the 1970s the government-owned Yongping copper mine began to invest on a large scale and to open its large open pit mine, a great part of the area originally belonging to the village of Gangzhoucun was confiscated in order to use it as a dump for waste material from the mine. Since this waste material partly consisted in copper sulphate bearing earth and sulphate ores too poor for which were there for the first time exposed to weathering, soon ideal conditions for the execution of wet copper production were given. Apparently around the year 2002, an Investor by

[475] All information is obtained from a news article written by Yin Jian 尹劍 for the website Dajiangwang 大江網, see Yin Jian (2013).

the name Yu Jincheng 余金城, who was not a local of the village, signed a lease with the mine, which allowed him to construct wet copper production facilities on the land confiscated by the mine and to utilize the enriched water streams from the waste dump for wet copper production. Together with his six brothers, he developed these facilities into a prospering and profitable enterprise. Other families from the village carried out the process on a much smaller scale, mostly without formal leases beside him in the same area.

In 2012 a certain Hou Shiqun 侯世群 gathered about 100 villagers as small investors each contributing 3000 Yuan to his plan and applied to the village authorities for permission to open a tree plantation exactly in the same place, where the Yu brothers had installed their vitriol water basin (*shuiwo* 水窩) underground. After the permission had been granted, he moved together with his followers and an excavator to the site in order to destroy Yu's water basin and wet copper production facilities. When he reached the basin, several dozens of people hired by the Yu brothers to defend the basin had already assembled. Before the conflict could escalate to a violent level, however, local officials from Yongping together with police units appeared – and watched, how Hou with his excavator destroyed the water basin.

In the aftermath, in order to "settle the conflict" between the villagers and the investor, all of Yu's facilities were confiscated and his exploitation lease was annulled. The government took over the operation of the facilities granting 15% of the profit to the Yu brothers redeeming them for their investment, 39% for the village administration to allow the villagers to benefit from the yields of their land. The remaining 46% of the profit belonged to the local government of Yongping town. It was mentioned that this proceeding followed precedents from another case in Yongping, which took place in 2006 under similar auspices but at this time did not reach any medial attention. It was however estimated, that beside the few officially licensed facilities around the waste dumps of the Yongping mine alone, up to 1300 people were involved into the small-scale production of wet copper.

The case shows, to what extent the struggle for vitriol water resources suitable for wet copper production until the present day can motivate actors from different sides. It is of course hard to evaluate the actions of these actors especially according to their rightfulness, because the underlying news article can surely not provide the entire picture. The investor may have obtained his lease under doubtful circumstances from the mine, which allowed him to monopolize his business while the villagers had to remain expropriated thus causing their just anger. The investor may just as well have obtained his lease justly but may have made astonishingly high profits which lead to the plan of other villagers and of the local government to grasp their share in these profits with whichever means necessary. It can, however be imagined, that similar conflicts may already have existed alongside wet copper production during the Song period, making this case a valuable instance for the understanding of the topic of this thesis beyond the scope of modern China alone.

X) The "Rhapsody of the Great Smelting"

For the study of wet copper production in Song China but also of many of the subjects surrounding it, the "Rhapsody of the Great Smelting" (*Daye fu* 大冶賦) can be considered to be the most valuable contemporary source. Therefore and due to its character of presenting the related information in a very elaborate form telling much about its appreciation and image during the time of its compilation, this outstanding text is attached to this thesis as a whole.

The following translation is based on preparatory work carried out by the author in the context of his Master thesis[476] it is followed by a literary German translation published in the mining journal "Der Anschnitt".[477]

1) Author and Work

A) Hong Zikui's Life

Hong Zikui 洪咨夔, style name Pingzhai 平齋, (1176-1236) has become famous to its posterity mainly as a poet producing works of the most various kind, among them many of a particularly critical nature towards the contemporary political system and society. His collected works were

[476] See Jost (2011).

[477] See Jost (2014).

compiled during his lifetime or shortly afterwards under the name *Pingzhai wenji* 平齋文集, in modern times, some of his poetry has been reedited, most importantly by the Qian Zhongshu 錢鍾書.[478]

Information on the life of Hong Zikui can be obtained most importantly from his biography in the *Song shi*[479], but also from many of his diary entries, which have survived as a part of his poetry collection.

Hong Zikui was a scholar-official in the service of the southern Song. Being a native of Yuqian 於潛 in Zhejiang, he successfully completed his *jinshi* exam in 1202 at the age of 26. After filling a minor position in Rugao 如皋, he was transferred to become the Director of the Raozhou 饒州 Prefectural School (present-day Poyang 鄱陽 in Jiangxi), where he stayed for eight years showing much activity in his work by for instance enlarging the grounds of the school and organizing the repairing a dam in its vicinity. In 2011 he was shortly called to the court to become a prince educator, but apparently due to his critical mind he fell in disgrace and had to leave his position. After two to three years of mourning for his deceased mother, for which he returned to his hometown, he attended another official exam in Yangzhou.

In the following years, Hong's career as an official was fairly successful. He served as Prefect of Longzhou 龍州 in Sichuan, a place also famous for its gold production, became Investigating Censor (*jiancha yushi* 監察禦史), later also Supervising Secretary (*jishizhong* 給事中) and

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478 See Qian Zhongshu 钱锺书 (2002), pp. 383-388. Qian comments that "Hong is a famous figure who attacked the ruthlessness of politics at his time. His collection has many works with irony on officials and clerks as well as deep awareness of the suffering of commoners. […] he often uses innovative and ingenious metaphors."

479 SS, chapter 406, biography of Hong Zikui.

even Minister of Justice. Hong Zikui was a Hanlin Academician (*hanlin xueshi* 翰林學士) and died 1236 at the age of 60.

B) Circumstances of Writing the *Daye fu*

The "Rhapsody of the Great Smelting" was completed in 1210 and sent to the court in Hangzhou, which was at that time ruled by emperor Ningzong (r. 1194-1224). It is apparent, that Hong Zikui wrote the poem with the intention to impress the court with his knowledge about the production of precious metals and monetary policy at the time of a severe monetary and economic crisis. Besides, the passages elucidating the emperor's beneficent role to the country, the function of his officials and after all the modesty of the author himself, all indicate that Hong Zikui pursued aims beyond the sphere of art for art's sake. His plan worked out: Chancellor Lou Yue 樓鑰 (1137-1213), one of the most powerful officials in the country at that time formally praised the poem and had the time of its compilation recorded so that it later earned a record in the *Song shi*.[480] Only several months later, Hong Zikui was transferred to the capital to work as a prince educator, a position close to the imperial family and surely with perspectives for further ascends.

According to the introductory words of the *Daye fu*, Hong Zikui gathered his knowledge about mining, minting and metallurgy during the seven years since his arrival in Raozhou mainly through his contact with the mint and the associated central administrative institutions (*yetai* 冶臺), which were located close to his school. This was surely true for some part of the information contained in the *Daye fu*, such as the descriptions of the

[480] SS, chapter 406, biography of Hong Zikui.

minting process and likely also many aspects of copper production, making this poem a particularly valuable eyewitness report. For numerous other parts, however, it can still be assumed that Hong Zikui relied on other older texts available to him. One of these texts is very likely to be the chapter about silver smelting in the Gazetteer of Longquan (*Longquan xianzhi* 龍泉縣志)[481]. Longquan was a district adjacent to the district of Raozhou and the respective Gazetteer was completed and printed in 1209, only one year before the *Daye fu* was written. It is of course possible that both texts go back to a common origin and that Hong Zikui was personally acquainted to He Dan 何澹, the compiler of the Gazetteer[482] or any of his collaborators. It is noticeable, however, that the choice of words and characters in the *Daye fu* and in the Gazetteer of Longquan especially in very technical contexts is for the chapter on silver very similar while it shows greater differences for the chapter on copper.

C) Transmission history

Within the collected works of Hong Zikui, the *Pingzhai wenji*, the *Daye fu* occupies the first place, expressing that already during the Song period it was considered to be the most important of Hong Zikui's works. Today two original editions of the *Pingzhai wenji*, which date back until the Song period, have survived. One of them is preserved in the *Tieqin tongjian lou*

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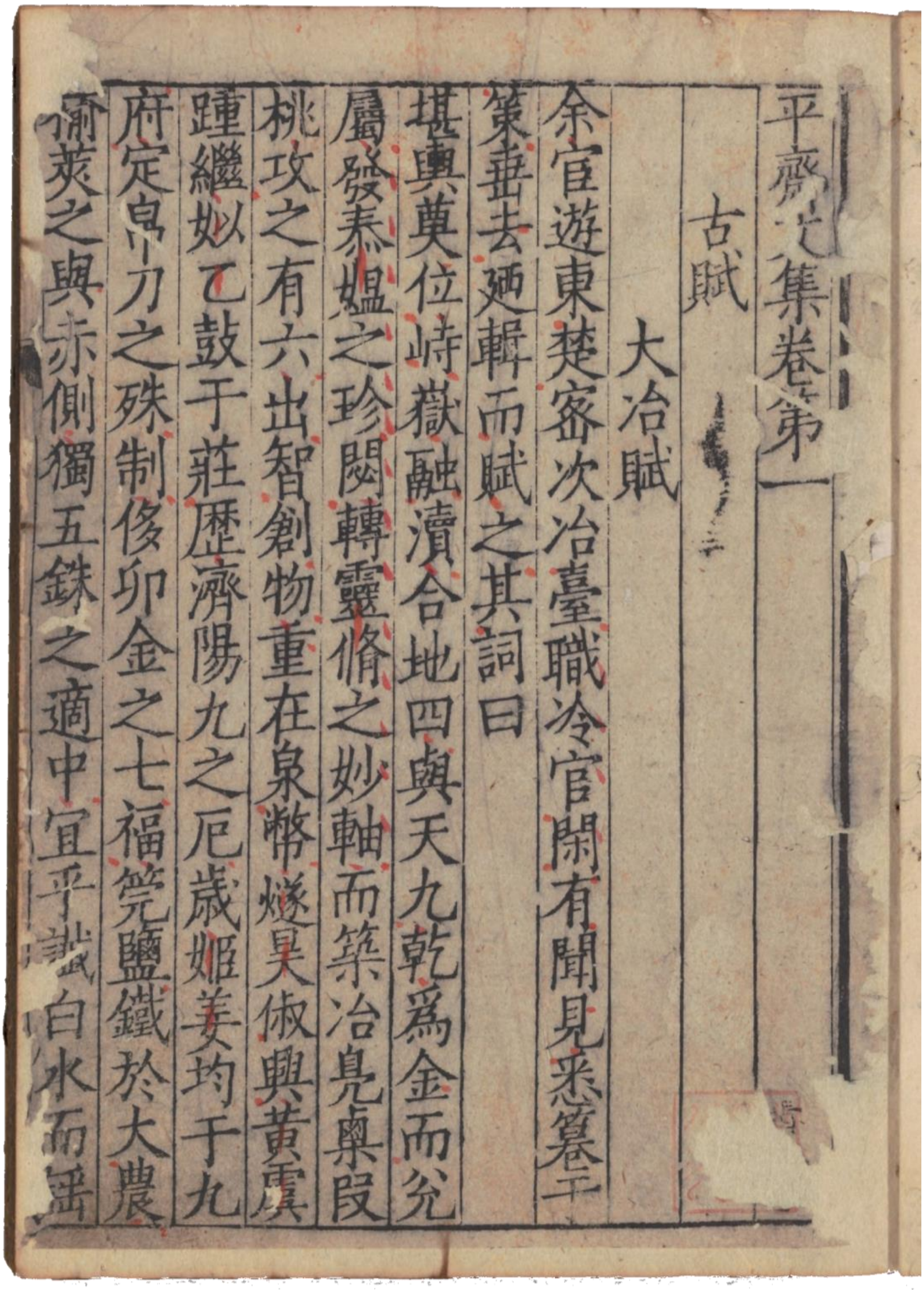
481 SYZJ / LQXZ, pp. 175-176.

482 In the Gazetteer of Longquan District from the Tongzhi reign-period, chap. 1, p. 1 it is said that the gazetteer of the same district from the Song period was written by a local person named He Dan 何澹 in the second year of the Jiading reign-period (1209). However, Wang Lingling argued that it was actually written by Chen Baipeng 陳百朋, who also lived during the Souther Song period. See also Wang Lingling (2001).

鐵琴銅劍樓 in Changshu 常熟, Jiangsu Province, the other one in the *Nigaku Bunko* 内閣文庫 in Tokyo. The version in Changshu is incomplete and was therefore for the compilation of a complete version in the *Sibu congkan* 四部叢刊 between 1919 and 1936 complemented with part of the version from Tokyo, which is more complete but in a worse state of preservation.[483] However, both versions contain the complete *Daye fu* and are identical into detail.

483 SBCK / PZWJ, introduction.


平齋文集卷第一

古賦

大冶賦

余宦遊東楚寄次冶臺職冷官閑有聞見悉纂于

策垂去迺輯而賦之其詞曰

堪輿奠位崎嶽融瀆合地四與天九乾爲金而兌

屬發泰爐之珍閟轉靈脩之妙軸而築冶鳧㮚段

桃攻之有六出智創物重在泉幣燧昊依與黃虞

踵繼姒乙鼓于莊歷濟陽九之厄歲姬姜均于九

府定鳧刀之殊制侈卯金之七福筦鹽鐵於大農

剜莢之與赤側獨五銖之適中宜乎識白水而[illegible]

Fig. 1: First page of the Song period woodblock print version of the *Daye fu* preserved in the *Nigaku Bunko* in Tokyo.
Source: National Archives of Japan.

2) Text and Annotated English Translation

A) Introduction

yú	huàn	yóu	dōng	chǔ			
余	宦	遊	東	楚	，		
mì	cì	yě	tái				
密	次	冶	臺	，			
zhí	lěng	guān	xián				
職	冷	官	閑	，			
yǒu	wén	jiàn	xī	zuǎn	yú	cè	
有	聞	見	悉	篹	于	策	。
chuí	qù						
垂	去	，					
nǎi	jí	ér	fù	zhī			
迺	輯	而	賦	之	。		
qí	cí	yuē					
其	詞	曰	：				

When I was sent to my post to Dongchu[484]

I was stationed close to the Mint[485],

When I had some spare time

I collected all the things I heard and saw into a notebook.

Short before I left,

I ordered them and made them into a prose poem.

It goes as follows:

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[484] Dongchu 東楚 stands for the region around Raozhou 饒州, nowadays Poyang 鄱陽 in Jiangxi. See Wang Shengduo (1999), p. 21.

[485] Hucker (1985), p. 577, item 7906.

B) Origins of Metallurgy and Minting

kān yǔ diàn wèi

堪輿奠位，

zhì yuè róng dú

峙嶽融瀆。

hé dì sì yǔ tiān jiǔ

合地四與天九，

qián wéi jīn ér duì shǔ

乾為金而兌屬。

fā tài ǎo zhī zhēn bì

發泰媪之珍閟，

zhuǎn líng xiū zhī miào zhóu

轉靈脩之妙軸。

ér zhù yě fú

而築、冶、鳧、

lì jiǎ táo

㮚、段、桃，

gōng zhī yǒu liù

攻之有六。

chū zhì chuàng wù

出智創物，

zhòng zài quán bì

重在泉幣。

suì hào chù xīng

燧昊俶興，

huáng yú zhǒng jì

黃虞踵繼。

sì yǐ gǔ yú zhuāng lì

姒乙鼓于莊歷，

jì yáng jiǔ zhī è suì
濟陽九之厄歲；

jī jiāng jūn yú jiǔ fǔ
姬姜均于九府，

dìng bó dāo zhī shū zhì
定帛刀之殊制。

chǐ mǎo jīn zhī qī fú
侈卯金之七福，

guǎn yán tiě yú dà nóng
筦鹽鐵於大農。

yú jiá zhī yǔ chì cè
榆莢之與赤側，

dú wǔ zhū zhī shì zhōng
獨五銖之適中。

yí hū chèn bái shuǐ ér yáo
宜乎讖白水而謠

huáng niú
黃牛，

zhào yù tiān zhī liù lóng
兆御天之六龍。

jìn yáng jué qǐ
晉陽崛起，

qí qín cì lú
齊秦賜爐。

hán sān tǐ zhī miǎo zhòu
含三體之邈籀，

yìn chū shēng zhī wàng shū
印初生之望舒。

suī huì chāng yīn zhōu yǐ biàn míng
雖會昌因州以辨名，

bú yì kāi yuán zhī jiù mó
不易開元之舊模。

bǐ qí qīng zhī
彼其輕之，

zé wéi xìng yè lěi zi
則為荇葉、耒子、

é yǎn xiàn huán
鵝眼、綖環，

fēng piāo shuǐ fú
風飄水浮；

zhòng zhī
重之，

zé bǐ lún liǎng zhù
則比輪、兩柱、

dà bù dà quán
大布、大泉，

zhí bǎi dàng qiān
直百當千。

chěng sī zhì yǐ jiāo rǎo
逞私智以膠擾，

fú qǐ zú yǐ cāo dà lì
夫豈足以操大利

zhī quán zāi
之權哉？

When Heaven and Earth fixed the positions

They towered up high mountains and created long rivers [by melting].

Combining the earthly four with the heavenly nine,[486]

The Hexagram "Heaven" stands for metal, which, however, [also] belongs to the Hexagram "Lake".[487]

By disclosing the hidden treasures of Tai[488] and Ao[489]

And by turning the mysterious pivot of the supernatural and the numinous,

There were six, namely the dagger maker Zhu, the arrowhead maker Ye, the bell maker Fu, the scale maker Li, the hoe maker Jia and the sword maker Tao,[490]

Who achieved it.

Among the things created with this wisdom,

The most important ones are coins.

Sui Renshi[491] and Fuxi[492] gave rise to them

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486 According to the theory of the Five Elements (*wuxing* 五行), the metal (*jin* 金) is produced by the "earthly four" and completed by the "heavenly nine". See LJZY chapter 14 (*yueling* 月令).

487 According to the theory of the Eight Trigrams (*bagua* 八卦) and its relations to the Five Elements, the Hexagram "Heaven" as well as the Hexagram "Lake" both stand for metal.

488 Tai 泰 is the god of heaven, see 泰一 or 泰壹, HYDCD, vol. 5, p. 1026, based on HGZ chapter 10 (*taihong* 泰鴻).

489 Ao 媪 is the mother goddess of earth, HYDCD, vol. 4, p. 387, based on HS chapter 22 (*liyue* 禮樂).

490 These six metal craftsmen are first mentioned in ZL chapter 6 (*dongguan kaogong ji* 冬官考工記).

491 Sui 燧 is Suiren 燧人, the discoverer of Fire, according to China's ancient mythology. See e.g. HFZ chapter 49 (*wudu* 五蠹).

And they were followed by the Yellow Emperor and by the Great Yu.

The royal family Si[493] and [Tian] Yi[494] cast coins at the Zhuang and Li mountains[495]

Which helped them overcome the disaster periods of nine unlucky years.[496]

Ji and Jiang [i.e. Zhou] divided the responsibilities [for financial andmonetary matters] on the Nine Institutions[497]

And established different currencies consisting of silk and knife coins.[498]

The suggestions for the Seven Benefits[499] were wasted under the Western Han[500]

And the monopoly over salt and iron was controlled by the Ministry of Revenue.

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492 Hao 昊 is Fuxi 伏羲, a culture hero and the first of the Three Sovereigns (*san huang* 三皇) of ancient China.

493 Si 姒 is the royal family of the Xia dynasty (ca. 2200-1800 BC).

494 [Tian]Yi [天]乙 is the founder of the Shang dynasty (ca. 1600-1046 BC).

495 The first emperors of the Xia- and Shang dynasties used gold from the Li 歷 and Zhuang 莊 Mountains to rescue their populations from flood and drought. See YTL chapter 1 (*ligeng* 力耕).

496 *Yangjiu* 陽九 means a period of disasters destroying the harvest. See HYDCD, vol. 11, p. 1062.

497 *Jiufu* 九府 stands for the nine governmental institutions established during the Zhou Dynasty in charge of monetary policy. See SJ chapter 129 (*huozhi liezhuan* 貨殖列傳) as well as SJZY.

498 *Bo* 帛 is the general name for silk and *dao* 刀 means knife coins. See HS chapter 24 (*shihuo zhi shang* 食貨志上).

499 The suggestions for the seven benefits (*qi fu* 七福) were made by Jia Yi 賈誼 (201 BC-169 BC) in order to reform the monetary policy.

500 *Maojin* 卯金 stands for the family name Liu 劉, which was the name of the imperial family of the Han Dynasty. See HS chapter 99, (*Wang Mang zhuan zhong* 王莽傳中), "Verily the word for Liu is made up of mao, metal (jin 金), and knife / 刀也、金、卯，之爲字’劉‘夫." HS / Dubs, vol. 3, p. 283.

In comparison with the elm pod coins[501] and red contour coins[502], only the Wuzhu coins[503] were appropriate.

They fitted well the prophecy of the White Water[504] and the folksong of the Yellow Buffalo[505]

and thus confirmed the world rule of the Six Dragons.[506]

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501 *Yujia* 榆荚 or "elm pods" is the name of a type of coins from the Western Han period (207 BC-9 AD). See HYDCD, vol. 4, p. 1186.

502 *Chice* 赤側, also called *chize* 赤仄, or "red contour" is the name of a type of coins during the reign of Han Wudi 漢武帝 (141-87 BC), which used pure copper at its outer edge. See SJ, chapter 30 (*pingzhun shu* 平準書).

503 *Wu zhu* 五銖, is the name of a type of coins, first cast during the reign of Han Wudi 漢武帝 (141-87 BC).

504 *Baishui* 白水 is short for *Baishui Zhenren* 白水真人, which was a prophecy of dynastic changes during and after the Wang Mang 王莽 reign (9-23 AD). Due to the similarity between the character qian 錢 and the imperial family name Liu 劉, which both have strokes of metal *jin* 金 and strokes of daggers *ge* 戈, Wang Mang ordered to replace the qian character by huo 貨 meaning "money". *Huoquan* 貨泉 was falsely read into 白水真人. Baishui was the hometown of Liu Xiu 劉秀, the first emperor of eastern Han and Zhenren stands here for the emperor. Thus this was regarded as the prophecy of the downfall of Wang Mang's reign. See HHS, chapter 1, (*guangwudi ji* 光武帝紀).

505 *Huangniu* 黃牛 stands for the folksong "Yellow Buffalo, White Belly - Wuzhu Coins Shall Return (*Huangniu baifu, wu zhu dangfu* 黃牛白腹，五銖當復." The Yellow Buffalo is Wang Mang (according to the colour attributed to his Xin Dynasty through the System of the Five Elements), white is the colour of his disloyal subordinate in Sichuan, Gongsun Shu 公孫述, who abolished the use of Wuzhu coins. See HHS chapter 13, (*wuxing zhi* 五行志).

506 *Yu tian zhi liulong* 御天之六龍 is a sentence from the Yi Jing 易經. *Liulong* means the six lines in the hexagram. See Hexagram of *qian* 乾, treatise on the Thwan, "[The sages] grandly understand [the connexion between] the end and the beginning, and how [the indications of] the six lines [in the hexagram] are accomplished, [each] in its season. [Accordingly] they mount [the carriage] drawn by those six dragons at the

[The Tang Empire] arose in Jinyang[507]

and the Princes of Qi[508] and Qin[509] were bestowed the right to set up [minting] furnaces.

[Coin legends] were written in three [different] styles

And bore the sign of the newly born crescent.[510]

Although from the Huichang period[511] onwards they were distinguished by the names [of their casting] prefectures [on the back],

They did not change the old pattern of the Kaiyuan[512] [coin on the front].

Concerning the light ones,

They were [called] "floating heart leaves", "ploughshares" , "goose eyes" and "thread rings", [513]

And they hovered in the wind and floated on the water;

As concerns the heavy ones,

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proper times, and drive through the sky /大明終始，六位時成，時乘六龍以御天." YJ / Legge, p. 213.

507 Jinyang 晉陽, nowadays Taiyuan 太原 was where Li Yuan 李淵, the founder of the Tang Dynasty, raised his troops.

508 Qi 齊 refers to the Prince of Qi, Li Yuanji 李元吉.

509 Qin 秦 refers to the Prince of Qin, Li Shimin李世民, the later Tang Taizong (r. 626-649).

510 During this time there was a crescent-shaped imprint on the back of every coin representing the queen's fingernail. See the THY chapter 89 (*huoquan* 貨泉).

511 Huichang 會昌 reign-period (841-846).

512 Kaiyuan tongbao 開元通寶, cast since 621, was the most important and the longest circulating coin of the Tang dynasty. See JTS, chapter 48 (*shihuo zhi shang* 食貨志上).

513 *Xingye* 荇葉 or "floating heart leaves", *leizi* 耒子or "ploughshares", *eyan* 鵝眼 or "goose eyes" and *yanhuan* 綖環 or "thread rings" were light coins used during the Song dynasty of the Northern and Southern Dynasties (420-479).

They were [termed] “wheel-like“, “two columns”, “big spades” and “big fountains”,

And they were in denominations from 100 to 1000.

Recklessly carrying out egoistic schemes and thus creating disturbances and havoc,

Is this really sufficient for grasping the right measures to build up the Common Weal?[514]

C) Foundation of the Song Dynasty

hào	cāng	jiān	dé	
顥	蒼	監	德	，
zhēn	rén	qǐ	zhuó	
真	人	起	涿	。
jù	wǔ	xīng		
聚	五	星	，	
mó	liǎng	rì		
摩	兩	日	。	
xū	fēng	yún		
噓	風	雲	，	
xuán	dǒu	jí		
旋	斗	極	。	
yí	kūn	lún		
夷	崑	崙	，	
dàng	míng	bó		
蕩	溟	渤	。	

[514] This refers to the practice of counterfeiting by commoners as well as by mint personnel. Counterfeiters cast coins of either decreased value or inferior alloys.The production of coins with a lower intrinsic value was was at times even accepted by the government and integrated into the respectibe regulations.

hú xiāng shōu bō
湖湘收波，

jiàn gé shī xiǎn
劍閣失險，

ér wáng shī fēi dù yú cǎi shí
而王師飛渡於采石。

lǎn liù cháo zhī wáng qì
攬六朝之王氣，

hùn jiāng nán zhī bǎn jí
混江南之版籍。

yě yǒu yǒng píng
冶有永平，

réng zhèn chǔ zé
仍鎮楚澤。

liè shèng chóng guī
列聖重規，

tóng wén yì guǐ
同文一軌。

qióng fú xiàng yú
穹符象瑜，

lěi yáng dié měi
絫鴹疊媺。

kuàng rén shēn qí lì jìn
卝人申其厲禁，

jiǔ mù xiū qí gòng fěi
九牧脩其貢篚。

yú shì jiān yǒu yǒng fēng
於是監有永豐、

yǒng tōng fù cái
永通、阜財、

fù mín 、 xī níng 、
阜民、熙寧、

guǎng níng 、 shén quán 、
廣寧、神泉、

bǎo quán 、 fēng guó 、
寶泉、豐國、

fēng yuǎn 、 fù mín 、
豐遠、富民、

huì mín ，
惠民，

hù fēn cuò zhì ，
眝分錯跱，

bù kě dān lùn 。
不可殫論。

Then on the azure sky[515], on [every] morning in the first month, Jupiter appeared in the east,[516]

and the perfected[517] arose in Zhuo.[518]

The five planets formed a great conjunction[519]

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515 *Haocang* 顥蒼 means heaven or sky. See HS chapter 100 (*xuzhuan shang* 敘傳上).

516 *Jiande* 監德, is an expression describing Jupiter when it arises in the east in the mornings of the first month of the year. See Shi Ji, chap. 27, Tianguan Shu 天官書. The first Emperor of the Song Dynasty, Zhao Kuangyin 趙匡胤, came from Hebei, which lies to the east of the ancient capitals. According to Yisi Zhan, chap. 4, In the place where Jupiter is located, there is somebody with virtue and blessed by heaven.

517 *Zhenren* 真人, the perfected, stands for the emperor. See SJ chapter 6 (*Qinshihuang benji* 秦始皇本紀).

518 Zhuo 涿, city in Hebei, nowadays Zhuozhou 涿州, is the hometown of Zhao Kuangyin.

and two luminaries were [shining] side by side.[520]

Gales arose and clouds

and the big dipper turned around the polar star.[521]

Even became the Kunlun Mountains

and tranquil the vast oceans.[522]

Dongting lake and Xiang River withdrew their waves,

[the passage of] Jiange lost its danger,[523]

and the imperial army flew over [Yangzi River] at Caishi.[524]

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519 *Ju wuxing* 聚五星 means, that the five planets, i.e. Mercury, Venus, Mars, Jupiter and Saturn, are appearing at the same time. This rare astronomical phenomenon was regarded as an auspicious sign. See ZSJN chapter 2 "Phoenixes appeared in the courtyards of the palace; the pearl grass grew, and the admirable grain flourished; sweet dews moistened the ground, and crystal springs issued from the hills; the sun and moon appeared like a pair of gems, and the five planets looked like threaded pearls /鳳凰在庭，朱草生，嘉禾秀，甘露潤，醴泉出，日月如合璧，五星如連珠." ZSJN / Legge, vol. 3, part I, chapter 4, p. 113.

520 *Mo liangri* 摩兩日 describes the phenomenon of two two suns appearing at the same time as it happened when Zhao Kuangyin stayed with his army at Chenqiao Yi 陳橋驛, where the coup leading to the founding of the Song dynasty took place. See SS, chapter 1 (*taizu ji yi* 太祖紀一).

521 The big dipper appears to every year turns once around the polar star with its stars being the closest ones to it. According to the daoist understanding, the polar star represents the emperor while the big dipper either represents his chariot or his highest feudatory nobles. See JS chapter 11, (*tianwen zhi shang* 天文志上).

522 *Ming[hai]* 溟[海] and *Bo[hai]* 渤[海], refer to the ocean in general. See HYDCD, vol. 6, p. 41.

523 Jiange 劍閣 is the strategically important mountain passage between Gansu and Sichuan.

524 Caishi[ji] 采石[磯] is a locality at the east bank of the Yangtze river nowadays belonging to Ma'anshan 馬鞍山 in Anhui. It was a ferry crossing and thus a strategically important place. See HYDCD. vol. 10, p. 1305.

Seized was the imperial Aura of six dynasties,[525]
and united the territories south of the Yangzi River.

Among the Smelting Offices there is Yongping,
which as before controls the region of Chu.
Every [following] emperor carried on his predecessor's work[526]
with common script and standard gauge.[527]
Heavenly tally and dragon tally,
With fine bird-style writing and sophisticated beauty.[528]
The mining officials tighten their strict prohibitions,
and the nine governors[529] prepare their tribute boxes.

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[525] *Liuchao* 六朝 are the six dynasties which had their capitals in Nanjing. They are: Eastern Wu Dynasty (222–280), Jin Dynasty (265–420), Song Dynasty (420–479), Qi Dynasty (479–502), Liang Dynasty (502–557), Chen Dynasty (557–589).

[526] *Chonggui* 重規 means, that the sun and the moon are both round. It is a metaphor referring to the continuing successive merit of two generations of emperors. See HYDCD, vol. 10, p. 372.

[527] *Tongwen gonggui* 同文共軌 means the empire-wide unification of the script and the track gauge of carriages. Metonymical it stands for the unification of the country. See LJ chapter 31 (*zhong yong* 中庸) "Now, over the kingdom, carriages have all wheels of the same size; all writing is with the same characters; and for conduct there are the same rules / 今天下車同軌，書同文，行同倫." ZY / Legge vol. 1, p. 424.

[528] *Qiongfu* 穹符 means divine tally. *Xiangyu* 象瑜 means a tally made of jade in the shape of an elephant. *Yang* 鴹 is the name of a bird in the legend, here it may be referring to the so called "Bird [feet] Writings" (*niaozhuan* 鳥篆), a type of characters used on seal engravings. *Lei yang die mei* 絫鴹疊媺 should thus describe the complicated and beautiful script on the seals.

[529] *Jiumu* 九牧 means nine governors and generally refers to local officials. See HYDCD, vol. 1. p. 726.

There are the following supervision offices for coinage:

"Eternal Prosperity", "Eternal Thoroughness", "Abundant Wealth", "People's Abundance", "Splendid Tranquillity", "Widespread Peace", "Fountain of Divinity", "Fountain of Treasures", "Prosperous State", "Prospering Far", "People's Enrichment" and "People's Benefit".

They are [all clearly] divided from each other but [also work closely] dovetailed, [here] they cannot be thoroughly discussed.

D) Auspiciousness of the Land

shí	zé	tí	fēng	zhī	guǎng			
時	則	提	封	之	廣	，		
dōng	zhěn	pán	mù					
東	枕	蟠	木	，				
nán	kòng	dān	xué					
南	控	丹	穴	，				
xī	kàn	tài	méng					
西	瞰	大	蒙	，				
běi	bó	zhù	lì					
北	薄	祝	栗	。				
dì	chǎn	wù	yí					
地	產	物	宜	，				
lǚ	chōng	tíng	shí					
旅	充	庭	實	。				
ér	wàn	bǎo	bì	cuì				
而	萬	寶	畢	萃	，			
mò	dōng	nán	zhī	yǔ	pǐ			
莫	東	南	之	與	匹	。		
gài	qí	zhōng	wēn	hòu	zhī	rén	qì	
蓋	其	鍾	溫	厚	之	仁	氣	，

yìng	jié	qí	zhī	fēn	yù		
應	絜	齊	之	分	域	。	
dǒu	niú	pī	shì	yǐ	jīng	guāng	
斗	牛	被	飾	以	晶	光	，
jiāng	hàn	guàn	shū	qí	líng	yè	
江	漢	灌	輸	其	靈	液	。
huái	hǎi	jīng	héng	zhī	rǎng		
淮	海	荊	衡	之	壤	，	
jué	gòng	sān	pǐn				
厥	貢	三	品	；			
kuài	jī	jù	qū	zhī	zhěn		
會	稽	具	區	之	畛	，	
qí	lì	jīn	xī				
其	利	金	錫	。			

Nowadays the vastness of the [empire's] domain
rests on the Pan tree[530] in the east,
controls Danxue[531] in the south,
looks over Taimeng[532] in the west
and approaches Zhuli[533] in the north.
On the land, [plenty of] goods are produced,
on the road, [plenty of] tributes[534] are delivered.[535]

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530 Panmu 蟠木 is a legendary tree growing in the farthest east. See HYDCD, vol. 8. p. 971.

531 Danxue 丹穴is a legendary place in the far south. See HYDCD, vol. 1, p. 687.

532 Taimeng 大蒙, is the westernmost place in the legend, where the sun sets. See HYDCD, vol.1,p.1321.

533 Zhuli 祝栗 is the northernmost place in the legend. See EY chapter 9, (*shi di* 釋地).

But no place can compare to the southeast,

where innumerable treasures are gathered.

The reason for that is, that its amassing of mild and magnanimous benevolent spirit

corresponds to its neat and well-ordered territorial division.

the Dou and Niu [stars][536] cover and adorn it with a sparkling splendour.

Yangtze and Han River irrigate it by contributing their divine fluid.

in the area between the Huai River and the Sea and between Jingzhou and the Heng Mountain,

the tribute consists in the three goods.[537]

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534 *Tingshi* 庭實 are the tributes presented in the imperial court. See YL chapter 9, (*gong shi dafu li* 公食大夫禮). "The general delicacies are laid out in the space within the tablet. The things set out in the court are laid outside the tablet. 庶羞陳于碑内，庭實陳于碑外." Yi Li / Steele, p. 255.

535 *Qieqi* 挈齊 means "the purity and equal arrangement of all things". See YJ (*shuo gua*) 說卦. "All things are made to issue forth in Kan, which is placed at the east. [The process of production] are brought into full and equal action in Sun, which is placed at the south-east. The being brought into full and equal action refers to the purity and equal arrangement of all things. 萬物出乎震。震，東方也。齊乎巽。巽，東南也。齊也者，言萬物之挈齊也." YJ / Legge, p. 425.

536 *Douniu* 斗牛 means dipper and buffalo in the twenty-eight mansions of Chinese astronomy. They correspond to the regions of Wu and Yue, nowadays Jiangsu and Zhejiang. See HYDCD, vol. 7, p. 324.

537 *San pin* 三品: The three goods are gold, silver and copper. See SHS chapter (*Yu Gong* 禹貢) "Its articles of tribute were gold, silver, and copper. 厥貢惟金三品." Shang Shu/Legge (1960), vol. 3, part II, p. 110.

In the region between the Kuaiji [mountain][538] and the Taihu Lake the benefit lays in [its] bronze.[539]

E) Establishment of Mining Institutions

hàn	tiě	guān	zhǎng	chéng	wǔ	shí		
漢	鐵	官	長	丞	五	十		
						yǒu	yī	
						有	一	，
ér	zhuān	qí	guān	yǐ	zhǔ	dān		
而	專	其	官	以	主	丹		
					yáng	zhī	tóng	
					陽	之	銅	；
táng	zhū	dào	zhì	lú	jiǔ	shí		
唐	諸	道	置	爐	九	十		
						yǒu	jiǔ	
						有	九	，
ér	zhòng	qí	shǐ	yǐ	zǒng	jiāng		
而	重	其	使	以	總	江		
					huái	zhī	tiě	
					淮	之	鐵	。
jié	suǒ	yǐ	guǎn	shān	hǎi	tiān		
皆	所	以	斡	山	海	天		
					dì	zhī	cáng	
					之	地	藏	，

[538] Kuaiji 會稽 is the name of a mountain near Shaoxing 紹興 in Zhejiang.

[539] *Jinxi* 金錫 does here not stand for gold and tin but for an alloy of tin (*xi*) with another metal (*jin*), which should in this case refer to the most commonly used tin alloy which is bronze.

chōng shào fǔ shuǐ héng zhī jī zhě yě
充少府水衡之積者也。

shěn huǒ dé zhī wàng lí
矧火德之王離，

xūn xié qì zhī jiā shēng
薰協氣之嘉生。

tóng bēn niú ér liú pò
銅犇牛而流魄，

yín zǒu lù ér chǔ jīng
銀走鹿而儲精。

qiǎo wù yǐn cuò
鈔鋈鈏錯，

dān gǒng zhī rù
丹汞之入，

fēi yī duān zhī kě míng
非一端之可名。

cáo yáo jiān tǒng
漕軺兼統，

zhào yú xīng guó
肇於興國。

dū tí mìng guān
都提命官，

fǎng yú xián píng
昉於咸平。

hé jiāng huái jīng zhè mǐn guǎng ér jiàn yī tái
合江淮荊浙閩廣而建一臺，

zé	jǐng	yòu	zhī	xiàn	dù			
則	景	祐	之	憲	度	。		
dōng	zhì	yú	ráo					
東	治	於	饒	，				
xī	zhì	yú	qián					
西	治	於	虔	，				
zé	yuán	fēng	zhī	zhāng	chéng			
則	元	豐	之	章	程	。		
lì	chún	xī	zhī	zōng	hé			
戾	淳	熙	之	綜	核	，		
shǐ	fù	náng	kuò	yú	yǒng	píng	yǐ	
始	復	囊	括	於	永	平	矣	。

The Han Dynasty's iron officials[540] – leading and assisting ones – were 51
and these officials were entrusted with the management of copper.[541]
The Tang Dynasty's circuits established 99 furnaces
and laid stress on its commissioners supervising the iron from the Yangtze and Huai River regions.
This was the way by which were administered under these two [dynasties] the treasures of Mountains, Oceans, Heaven and Earth,
and by which the Shaofu's[542] and the Shuiheng's[543] storages were filled up.

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540 *Tieguan* 鐵官 is the iron monopoly office, an agency which is commonly found in Commanderies (*jun* 郡) and Princedoms (*wangguo* 王國) and which is in charge of managing the state-controlled production and distribution of iron. See Hucker (1985), p. 499, item 6508.

541 *Danyang* 丹陽 is another name for copper, derived from a production place. See HYDCD, vol. 1, p. 678.

542 *Shaofu* 少府, lit. "lesser office" in contrast to the *dafu* 大府 or *taifu* 太府, the Chamberlain for the Palace Revenues, the Shaofu is an important post in the central government one of the prestigious Nine Chamberlains (*jiuqing* 九卿). It shared control over governmental revenues with the Chamberlain of the National Treasury (da

When the fire moral[544] brought forth[545] the flames[546] of prosperity,[547]
and when exuberant procreation by the harmonious aura imbued [the empire]
copper [was found] by a galloping buffalo[548] with a transient soul
and silver [was found] by a running deer[549] with a supernatural spirit.
Gold, silver and tin appear mixed,
cinnabar and mercury join
and not one single explanation can be given [for these phenomena].
The state control of both water and land transport [of metals] was institutionalized in the Xingguo[550] reign period

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sinong 大司農), being charged with providing for the Emperor's personal needs, maintaining and provisioning the imperial palace, etc. See Hucker (1985), pp. 414-415, item 5097.

543 *Shuiheng* 水衡 is the Court of the Imperial Gardens, who was in charge of the production and circulation of copper coins. See Hucker (1985), p. 438, item 5495, *Shuiheng san guan* 水衡三官, item 5497, *Shuiheng duwei* 水衡都尉.

544 *Huode* 火德 means "fire moral". According to the system of the Five Elements, every Dynasty was related to an Element. The Song Dynasty was related to fire.

545 *Shen* 矧 in this place should be borrowed to replace either *sheng* 生 or *yin* 引, which means "to produce" or "to create."

546 *Li* 離 means fire, see HYDCD, vol. 11, p. 881.

547 *Wang* 王 is the same with the character 旺, meanin "prosperous."

548 *Tongbenniu* 銅奔牛 refers to a legendary story which happened in Kuaiji 會稽 in Zhejiang. According to the story, people chased a copper-coloured buffalo and by this discovered a copper deposit on the mountain. See KJZ chapter 9.

549 *Yinzoulu* 銀走鹿 refers to a legend in Dexing 德興, Jiangxi, telling that Zhang Meng 張蒙 during the Sui period (581-618) hunted a white deer and lost it but found a silver outcrop. The place later became an important silver mine. See JXTZ chapter 109.

550 Taiping xingguo 太平興國 reign-period (976-984).

and the appointment of minting and mining officials[551] was started in the Xianping[552] reign period.

Jiang, Huai, Jing, Zhe, Min and Guang[553] were all united and one office was established for them;

these were the decrees and regulations of the Jingyou[554] reign period.

The east was governed from Raozhou, the west was governed from Qianzhou;[555]

these were the rules and directives of the Yuanfeng[556] reign period.

Only when it came to the comprehensive investigations of the Chunxi Reign period,[557]

was [the administration] united again in Yongping.

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551 *Duti* 都提 is a short form of an official title named *Du tidian kengye zhuqian yu tixing xuguan* 都提點坑冶鑄錢與提刑序官. This official was in charge of mining and minting. See ZZT, category of *da* 大. See also WXTK, chapter 62, *zhiguan shiliu* 職官十六. Hucker (1985), p. 543, items 7289, 7294, 7295.

552 Xianping 咸平 reign-period (998-1003).

553 Jiang 江 is the south of nowadays Jiangsu, Huai 淮 is the part of nowadays Jiangsu between the Yangtze and the Huai River, Jing 荊 is nowadays Hubei, Zhe 浙 is nowadays Zhejiang, Min 閩 is nowadays Fujian, Guang 廣 is nowadays Guangdong and Guangxi.

554 Jingyou 景佑 reign-period (1034-1038).

555 Qian 虔 is nowadays Ganzhou 贛州, Jiangxi.

556 Yuanfeng 元豐 reign-period (1078-1085).

557 Chunxi 淳熙 reign-period (1174-1189).

F) Mines

huáng qí zǐ gài
黄旗紫蓋，

tiān yùn yǒu shǔ
天運有屬；

lǐ quán qì chē
醴泉器車，

dì líng zì yù
地靈自鬻。

yě chăng zhī shèng
冶場之盛，

míng zài guăn guān zhě
名在斡官者，

fēn fēn qí kě fù
紛紛其可覆

qiān shān méng shān
鉛山、濛山、

shí yàn cén shuǐ
石堰、岑水、

zhāo bǎo fù bǎo
昭寶、富寶、

bǎo chéng bǎo ruì
寶成、寶瑞、

shuāng ruì jiā ruì
雙瑞、嘉瑞、

dà tǐng dà jì
大挺、大濟、

yǒng xīng xīn xīng
永興、新興、

xīng guó xīng lì
興國、興利、

dà fù guǎng fù
大富、廣富、

tōng lì tōng jì
通利、通濟。

jiān wù kēng jǐng
監務坑井，

dài jī wàn jì
殆幾萬計。

yǒu sè ér fēng
有嗇而豐，

yǒu xīng ér fèi
有興而廢。

jǔ sī yǐ zhān
舉斯以旃，

tè qí fán lì
特其凡例。

rán huò tiě shān zhī yùn tóng
然或鐵山之孕銅，

huò tóng kēng zhī huái jīn
或銅坑之懷金；

huò cān yín ér xié fā
或參銀而偕發，

huò	qiě	jìn	ér	qiě	lín		
或	且	浸	而	且	淋	。	
cì	lí	yáng	jǐn	zhī	yán	lì	
賜	蠡	羊	僅	之	言	利	，
mò	néng	yán	jī	ér	jí	shēn	
莫	能	研	幾	而	極	深	。

Yellow banners and purple roofs[558] –
the fate of heaven has found its destiny,
sweet springs, implements and chariots[559] –
the divinity of earth reveals its gifts.
The prosperity of mines and smelters
finds its fame in the administrative agencies,[560]
large is their enumeration:

Lead Mountain[561], Mist Mountain[562], Stone Dam[563], Hill Water[564], Brilliant Treasure[565], Wealthy Treasure[566], Successful Treasure[567], Auspicious

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[558] *Huangqi* 黄旗 and *Zigai* 紫蓋, the "yellow banners and the purple roofs", indicate the carriage of the Son of Heaven, i.e. the emperor. They are both auspicious signs. See HYDCD, vol. 12, p. 967 and vol. 9, p. 813.

[559] *Qiche* 器車, means "implements and chariots." They are regarded as auspicious signs which appear in a flourishing age (*sheng shi* 盛世). See LJ chapter 9 (*liyun* 禮運), "Heaven sent down its fattening dews; earth sent forth its springs of sweet wine; hills produced implements and chariots / 天降膏露，地出醴泉，山出器車." LJ / Legge, p. 392.

[560] *Guanguan* 斡官 is an official title established under the Han dynasty in charge of the monopoly of salt, iron and alcohol. See HS chapter 19, (*baiguan gongqing biao shang* 百官公卿表上).

[561] Yanshan 鉛山, in Jiangxi.

Treasure[568], Double Fortune[569], Blessed Fortune[570], Great Outstandingness[571], Great Welfare[572], Eternal Thriving[573], New Thriving[574], Thriving Country[575], Thriving Profit[576], Great Wealth[577], Broad Wealth[578], Thorough Profit[579], Thorough Welfare[580].

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562 Mengshan 濛山, in Shandong.

563 Shiyan 石堰, in Hubei.

564 Censhui 岑水, in Guangdong.

565 Zhaobao 昭寶.

566 Fubao 富寶.

567 Baocheng 寶成.

568 Baorui 寶瑞.

569 Shuangrui 雙瑞.

570 Jiarui 嘉瑞.

571 Dating 大挺.

572 Daji 大濟, in Fujian.

573 Yongxing 永興, in Hunan.

574 Xinxing 新興 in Fujian.

575 Xingguo 興國.

576 Xingli 興利, in Jiangxi.

577 Dafu 大富 in Guangdong.

578 Guangfu 廣富.

579 Tongli 通利.

580 Tongji 通濟.

As to the adits and pits to be inspected and cared for,
they probably amount to close to ten thousand.
Some are poor, others are rich,
some are thriving, others abandoned.
Those mentioned here in praise,
are only representative examples.

Sometimes iron mountains are pregnant with copper,
or copper adits hold gold in their womb;
sometimes [copper]appears intermixed with silver,
or is leached out and precipitated.

When Duanmu Ci[581], Fan Li[582], Sanghong Yang[583] and Kong Jin[584] talk about profit,
none of them is able to explain [this] to the finest detail and to its ultimate depth.

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581 Ci 賜 is Duanmu Ci 端木賜, known as Zigong 子貢, a student of Kongzi, famous for his eloquence and his abilities as a merchant.

582 Li 蠡 is Fan Li 范蠡, an advisor in the state of Yue during the Spring and Autumn Period. He had been taken as a hostage to the state of Wu together with King Goujian 勾踐 of Yue. Three years later they came back and he helped Goujian to carry out reforms. At last Yue was able to defeat the state of Wu.

583 Yang 羊 is Sang Hongyang 桑弘羊 (c. 152-80 BC), a prominent official of the Western Han Dynasty, who served Emperor Wu 武帝 and his successor Emperor Zhao 昭帝. He is most famed for his economy policies, the best known of which include the state monopolies over iron and salt.

584 Jin 僅 is Kong Jin 孔僅, an official during the Western Han Dynasty and the main executive official of the salt and iron monopoly. See ZZTJ chapter 19 (*Hanji shiyi* 漢紀十一).

G) Gold

dàn jiàn tài jīn yǒu zhōu
但 見 汰 金 有 洲 ，

táo jīn yǒu gǎng
淘 金 有 崗 ；

ruì jīn yǒu jiān
瑞 金 有 監 ，

tōng jīn yǒu chǎng
通 金 有 場 。

yè bǎo qì ér guàn hóng ní
曳 寶 氣 而 貫 虹 蜺 ，

yì hū lín zhǐ niǎo tí zhī xiáng
溢 乎 麟 趾 裹 蹏 之 祥 。

fēng chéng zhī huáng
豐 城 之 黄 ，

càn yān cuō cuō
璨 焉 瑳 瑳 。

qiū jú rǎn shuāng
秋 菊 染 霜 ，

hán yīng yù duò
寒 英 欲 墮 。

luò tíng zhī zǐ
落 亭 之 紫 ，

làn yān jiǎn jiǎn
爛 焉 睷 睷 。

chūn pú chuǎng shuǐ
春 蒲 闖 水 ，

róng yá shàng duǎn
茸 芽 尚 短 。

lè ān jīng liú
樂安精鏐，

tāi ruì kēng gǔ
胎瑞坑谷。

jùn qí qì yǐ cǎi zhí
濬埼磧以採摭，

huà shàn shā ér pī lù
畫墠沙而披漉。

dà rú luò qí zhī dòu
大如落萁之豆，

xiǎo rú tuō bǐ zhī sù
小如脫粃之粟。

qīng rú fū zhī qù hé
輕如麩之去麧，

xì rú chén zhī shēng qū
細如塵之生麯。

dèng zhī tài zhī
澄之汰之，

shū shēn pú jū
倏胂蒲掬。

qú yáng zé xiǎn
渠陽澤銑，

yù qí xī dòng
毓奇溪洞。

xún miáo jì zhuó zhī suì
尋苗罽汋之邃，

pò dí tán bì zhī yōng
破的磹壁之壅。

xìn yǐ huǒ
焮以火，

zé liú zhī tiě lóng zhī liè
則流脂鐵籠之烈；

cuì yǐ shuǐ
淬以水，

zé chōng méi qiān chǔ zhī zhòng
則舂糜鉛杵之重。

jí dìng lǚ chén
吉挺旅陳，

fú cǎi fēi dòng
符采飛動。

zhù shén dǐng ér zhì jiā liàng
鑄神鼎而制嘉量，

shì wéi wàn shì bù qióng zhī yòng
是為萬世不窮之用。

As to washing out gold, there are sandbanks,
and for panning it, there are hillocks.
In Ruijin[585] there is a mining prefecture[586]
Tongjin has a monopoly agency.[587]
The Qi of the treasure is brought to light glittering and like reflecting a rainbow,
more abundant than the auspiciousness of Qilin feet[588] and horse hooves.[589]

---

[585] Ruijin 瑞金, nowadays in Jiangxi, was established as a prefecture in 904, because of the auspicious sign of finding gold here. See JXTZ, vol. 3.

[586] *Jian* 監 is an industrial prefecture, prefixed with a place name, identifying a prefecture-level agency in an area where the preeminent economic enterprise was a mine, a salt well, or something of the sort that required the special attention of local officials. See Hucker (1985), p. 145, item 786.

[587] *Chang* 場, a name for the places of boiling salt, smelting iron or making alcohol as well as their monopolized selling places during the Five Dynasties and the Song. See WDHY chapter 27 (*yan tie zatiao xia* 鹽鐵雜條下). See also SS chapter 134 (*shihuo zhi xia san* 食貨志下三).

The yellow [gold] from Fengcheng, sparkling there so brilliant;
like the chrysanthemum in autumn imbued with white frost
and with its icy flakes already on the verge to fall down!
The purple [gold] of Luoting[590], shining there so bright;
like the bulrush in spring stretching its head out of the water,
with its downy buds still being short.[591]
The fine, pure [gold] of Le’an,
auspiciousness growing like an embryo in pits and ravines.

The shoals between winding river banks are dredged in order to pick and pluck [the gold out of the sand]
and the sand on the flat land is divided up and ablated.
[Nuggets] are large like beans fallen from a bean stalk,
or small like husked millet grain,
or light like the smallest flakes of grain chaff
or tiny like pieces growing out of ferment.[592]
They are sedimented and washed out,

---

588 *Linzhi* 麟趾, gold in shape of Qilin feet.

589 *Niaoti* 褭蹏, gold in shape of the horse hooves. They are both regarded as auspicious. See HS chapter 6 (*wudi ji* 武帝紀).

590 Luoting 落亭 is in Ancheng county 安城縣, Henan, where purple gold was produced. See TPHYJ chapter 109 (*Jiangnan Xidao, Luling xian Luoting shi* 江南西道, 廬陵縣,落亭石). This book quotes another already lost source, the Record of Ancheng (*Ancheng Ji* 安成記) by Wang Liezhi 王烈之: “[…] the Luoting Rock, above it there are glossy Lingzhi mushrooms, beneath it there is purple gold. 落亭石，上有芝草，下有紫金.“

591 This description should refer to the shape of outcrops.

592 *Fu* 麩 means small pieces of grain chaff or bran. He 麧 are the bigger pieces of chaff or bran. Thus “fu“ without “he“ means the smaller part of the bran, which are the very tiny pieces.

quickly, with a reed mat held in both hands.
the lustrous gold of Quyang,
rare [preciousness] gestated in rivulets and grottoes.
Veinlets are searched in holes, which are sometimes filled with water,[593]
And their ends are smashed within the fillings of the earthen walls.
Fire is used to burn it,
so that the fat flows out like through the intense heat of an iron cage[594],
and water is used to quench it,
so that it is pounded [and becomes brittle] like through the heaviness of a lead pestle.[595]

Then the propitious ingots are displayed,
and [their] lustre flares up.
Cast to divine tripods and made to the Good Measure[596],
they will provide inexhaustible benefit for ten thousand generations.

---

593 *Jizhuo* 瀱汋 means the well sometimes has and sometimes has no water. See HYDCD, vol. 6, p. 214.

594 *Tielong* 鐵籠 is a cage made of iron, used as instrument of torture. People are locked inside of it and heated over a fire. See ZZTJ chapter (*Houliang taizu qianhua yuannian* 後梁太祖乾化元年).

595 The Method described here is Firesetting. The ore-bearing rock is heated with a fierce fire and the quenched very fast with cold water. This makes the rock fall in pieces by itself or at least makes it brittle enough to be broken with hammer and chisel easily.

596 This refers to the establishment of standard capacity measuring devices, which were of great importance for the legitimacy and the well-being of the state. See HS chapter 21, (*lüli zhi shang* 律歷志上).

H) Silver

yǐ zhì yín chéng yǒu chăng
以 至 銀 城 有 場 ，

yín xié yǒu kēng
銀 斜 有 坑 ，

yín yù yǒu wù
銀 玉 有 塢 ，

yín zhàng yǒu shān
銀 嶂 有 山 。

bǎo jī zhāng wàn dòu zhī kōng dòng
寶 積 張 萬 竇 之 空 洞 ，

tiān shòu yǐ yī zhù zhī cuán wán
天 壽 倚 一 柱 之 巑 岏 。

lì yán qiáng ér fú gù
立 巖 牆 而 弗 顧 ，

kăi xún lì ér wàng ān
慨 徇 利 而 忘 安 。

lóng lù shēn rù
襱 路 深 入 ，

gé dào héng niè
閣 道 橫 躡 。

gōu dēng bì fēng ér shàng zhào
篝 燈 避 風 而 上 照 ，

liáng gàng chā shuǐ ér xià yā
梁 杠 插 水 而 下 壓 。

hù xiāo shēn jǐng zhī fù
戽 枵 深 穽 之 腹 ，

pào lè pián shí zhī xié
炮 泐 骿 石 之 脅 。

jié tiào wā qí bú xì
捷跳蛙其不繫，

zhé cāng rán ér kě niè
磔蒼髯而可鑷。

duì shān jí kuàng ér yīn léi
碓山藉礦而殷雷，

táo chí jiǎo nián ér fēi shà
淘池攪粘而飛霎。

liú jǐng dǎo zhú
流景倒燭，

xīng xīng yè yè
星星曄曄。

shāo jiào shú
燒窖熟，

ān lú liè
盦爐裂。

qiān tuó fèi
鉛駞沸，

huī kē fā
灰窠發。

qì chū zǒu yú yān yún
氣初走於煙雲，

huā xú fān yú shuāng xuě
花徐翻於霜雪。

tā shān mò yōu
它山莫優，

zhū tí zé liè
朱提則劣。

yú yǐ gòng wáng fǔ fěi bān
于 以 供 王 府 匪 頒

zhī yòng
之 用 ，

yú yǐ bǔ yě tái dài běn
于 以 補 冶 臺 貸 本

zhī quē
之 闕 。

shì èr pǐn zé rán yǐ
是 二 品 則 然 矣 。

There is a Yincheng[597] smelter,
there is a Yinxie[598] pit,
There is a Yinyu[599] basin,
there is a Yinzhang[600] mountain.
The Baoji[601] [mine] displays [itself] through empty caves with ten thousand holes,

---

597 Yincheng 銀城 is the name of a former county belonging to Dexing, Jiangxi. see DSFYJY chapter 85 (*Jiangxi san* 江西三), p. 3956.

598 Yinxie *keng* 銀斜坑 is a mine that was located in Yongfu county 永福縣 (nowadays called Yongtai 永泰 in Fujian. It opened in 1115. See CXSSZ vol. 14 (*banji lei wu* 版籍類五, *luhu kengye fu* 爐戶坑冶附).

599 Yinzhang shan 銀嶂山, is a mountain belonging to the prefecture of Linjiang 臨江府, nowadays Jiangxi. See DSFYJY vol. 87.

600 Baoji 寶積 is the name of a silver mine in nowadays Fujian, the exact location is unclear. See WASWJ vol. 100 (*muzhi* 墓誌), *Tuntian yuanwailang zhishi Yu jun muzhiming* 屯田員外郎致仕虞君墓誌銘.

and the Tianshou [mine] leans on a high mountain looking like a pillar.[602]
Standing on its steep wall one does not look down,
fervently pursuing profit while forgetting about safety.
Entering through steep shafts,
and stepping in through even adits.
The fire in the bamboo lamp ducks away from the wind and shines upwards,
the timber beams are stuck into the water and are pressed downwards.

By using buckets, the belly of the pit is drained
and by using firesetting, the ribs of the solid rock are cracked.
Like a quickly jumping frog, but not fastened with ropes[603]
and like a cut grey beard, but can be picked up with tweezers.[604]
Like roaring thunder, the pounding of the rock and the collecting of ore
and like splashing rain, the washing in the pool and the stirring of paste.
Shining gloss[605] then reflects the light
And stars are sparkling.
When the baked silver-rice balls[606] are done,

---

601 Tianshou 天壽 is the name of a silver mine in Zhenghe county 政和縣, Fujian. See BMTZ chapter 24 (*kengye* 坑冶) Zhenghe county 政和縣.

602 *Cuanwan* 巑岏 means "high and sharp mountain".

603 According to Wang Lingling (2004), p. 360, this refers to the use of a bucket pump called *hudou* 戽斗, which could have been used to prevent the flooding of underground mines. This is possible but not necessarily true, because it is mentioned, that a frog is jumping and is not fastened with a rope. It can thus just be said, that buckets were used for the drainage of mines.

604 This description refers to the small broken pieces of rock spread on the floor after the firesetting and quenching is carried out.

605 *Liujing* 流景 means "shining gloss". See WX vol. 2, *Xijing fu* 西京賦 (Rhapsody of the Western Capital) by Zhang Heng 張衡.

then the 'An'-shaped[607] furnace splits.

When the lead lumps[608] boil, then the ash nest opens.

When the Qi starts to leave with a smoky cloud, then the flowers slowly turn into snow.[609]

None of the other mines is superior to it, even Shuti[610] is inferior.

It is taken to supply the imperial treasuries' practice of bestowing [silver upon officials][611]

---

606 *Jiaotuan* 窖团 stands for silver-rice balls. See SYZJ / LQXZ, p. 176. "[The 'ore pulp'] is mixed with [thick] rice porridge [and formed into pieces] round and as big as a fist. These are arranged ontop of charcoal, then another [layer as thick as] one *chi* of charcoal is used to cover them. One starts the fire from the dawn on [and lets it burn] until the afternoon (15-17), then quenches it and waits until it is cold. [The result] is called *jiaotuan* (silver-rice-ball). /礦肉用米糊搜拌，圓如拳大，排於炭上，更以炭一尺許覆之，自旦發火，至申時住火候冷，名窖團。

607 *An*盦 is an ancient type of container. See HYDCD, vol. 7, p. 1473.

608 *Tuo* 駞 is the same as 駝. It means "lead lumps". See SYZJ /LQXZ, p. 176. "One boils and smelts the melt until it is done, after a good while, uses water to extinguish the fire. Then silver and lead are together as one, this is then called 'lead lumps'. / 烹煉既熟，良久，以水滅火，則銀鉛為一，是謂鉛駝。" See also TXJGLBS chapter *Guangdong xia* 廣東下.

609 A similar phenomenon is also mentioned in SYZJ /LQXZ, p. 176. "it can be observed, how on top of the liquid, air in the shape of a smoke cloud appears. [This air] wafts and moves [around] restlessly. After a long time it disperses a little, then snowflakes arise in the bubbles. /望泓面有煙雲之氣，飛走不定，久之稍散，則雪花騰湧。" Differently from the *Daye fu*, this description does not mention a flower (*hua*花) and snow (*xue*雪), but only snowflakes (*xuehua*).

610 Shuti 朱提 is the name of the high quality silver produced at the Shuti mountain in Zhaotong 昭通, Yunnan. See HS chapter 24, (*shihuo zhi xia* 食貨志下). "The Shuti silver, weighing eight liang, is the first class. Its value is 1580 coins. /朱提銀重八兩爲一流，直一千五百八."

611 *Fenban* 匪頒: 匪 is borrowed to replace the character 分. Fenban means to distribute, to bestow. See ZL chapter 1, (*tianguan zhongzai* 天官冢宰), "Use the nine regulations to

or it is taken to cover the mining offices’ accounting deficits.[612]

This is what the product of the second grade[613] is like.

I) History of Copper

qǐng	fù	jiū	tóng	zhī	wéi	shuō		
請	復	究	銅	之	為	說	：	
liú	bì	cuì	bū	táo	zhī	sǒu		
劉	濞	萃	逋	逃	之	藪	，	
shàn	cǎi	shān	zhī	fù				
擅	採	山	之	富	，			
ér	wú	zhī	chǎn	fēng	yú	yù	zhāng	
而	吳	之	產	豐	於	豫	章	。
zhuō	shì	zhēng	wáng	zhě	zhī	lì		
卓	氏	争	王	者	之	利	，	
gù	qí	rén	zhī	yè				
錮	齊	人	之	業	，			
ér	shǔ	zhī	chǎn	fù	yú	lín	qióng	
而	蜀	之	產	阜	於	臨	邛	。
ōu	zǐ	pò	chì	jǐn	zhī	shān		
歐	子	破	赤	堇	之	山	，	
hé	ruò	yē	zhī	xī				
涸	若	耶	之	溪	，			

adjust the wealth. […] The eighth one is called ‘Regulation of Distribution and Bestowal’. / […]以九式均節財用[…]八曰匪頒之式.“

612 This should refer to the deficits caused by advancing investment funds for the mines.

613 *Er pin* 二品: The *san pin* 三品 are the “Three Grades” or “Three Goods”, which means gold, silver and copper. Thus *er pin*, the “Second Grade” stands for silver. See Shang Shu, chap. Yu Gong 禹貢, “Its articles of tribute were gold, silver, and copper / 厥貢惟金三品.” Shang Shu/Legge (1960), vol. 3, part II, p. 110.

ér yuè zhī chǎn bù zhǐ yú
而越之產不止於

mò yé gān jiàng
鏌鋣干將。

qián bì huò zào yú chǔ jìn
錢幣或造於楚晉，

yě zhù duō chū yú qí liáng
冶鑄多出於齊梁。

fú xī yǐ lái
伏羲以來，

tóng shān sì bǎi liù shí yǒu qī
銅山四百六十有七。

jīn zhī dà yào
今之大要，

bú guò jué sè zhī yǒu sān
不過厥色之有三。

Let us now as well investigate and explain Copper:

The production of the state of Wu[614] flourished in Yuzhang,

where Liu Bi[615] gathered criminals and fugitives in a [mountain] retreat

and monopolized the mining wealth without authority.

The production of the state of Shu[616] was rich in Linqiong[617],

614 Wu 吳 was the kingdom of Liu Bi 劉濞. The domain of Wu consisted in three regions, i.e. Kuaiji jun 會稽郡, Yuzhang jun 豫章郡 and Danyang jun 丹陽郡.

615 Liu Bi 劉濞 (216 BC -154 BC) was a nephew of Emperor Gao of Han 漢高祖 enfeoffed with the title Prince of Wu. During the reign of the Jing Emperor 景帝 (156-141 BC), he initiated the Rebellion of the Seven States to resist the centralizing policies. He was defeated and killed. See HS vol. 35 (*wuwang Liu Bi* 吳王劉濞).

616 Shu 蜀 is nowadays Sichuan.

where the Zhuo Family[618] aspired [at the same] benefit as the Sovereign,
and monopolized the common peoples' industries.[619]
Ou Yezi[620] cut into the mountains of Chijin
and dried up the stream of Ruoye,[621]
so that production of the State of Yue was not only limited to [the Swords of] Moye and Ganjiang.[622]
Some of the coins were made in the Chu[623] and Jin[624] regions,

---

617 Lingqiong 臨邛 is nowadays Qionglai 邛崍 in the southwest of Chengdu Basin in Sichuan.

618 Zhuoshi 卓氏 was a merchant family from Zhao 趙 since the end of the warring states period. In 228 BC when the Qin conquered Zhao, the Zhuo family moved to Qionglai in Shu, nowadays Sichuan, and made a fortune through iron mining and commerce. See SJ chapter 129 (*huozhi liezhuan 69* 貨殖列傳第六十九).

619 *Gu qi ren zhi ye* 錮齊人之業 is a sentence from HS chapter 91 (*huozhizhuan 61* 貨殖傳第六十一), "Upwards they wrest advantages from the emperor, downwards they monopolize the property of the commoners, these are both unthrifty and presumptuous infamies against the law. 上爭王者之利，下錮齊民之業，皆陷不軌奢僭之惡."

620 Ou Yezi 歐冶子 was a legendary master of sword-making during the Spring and Autumn Period. See YJS chapter 11 (*yuejue waizhuan ji baojian 13* 越絕外傳記寶劍第十三).

621 The Chijin Mountain 赤堇山 and the Ruoye Stream 若耶溪 are located to the southeast of Shaoxing 紹興, Zhejiang, where Ou Yezi cast his swords. "When they made this sword the mountain of Chijin burst open to bring forth tin. The stream at Ruoye dried up and brought forth copper /當造此劍之時，赤堇之山，破而出錫，若耶之溪，涸而出銅." YJS / Milburn, p. 281.

622 Gan Jiang 干將 and Mo Ye 鏌鋣 were a sword smith couple in the Spring and Autumn Period and also the names of the famed twin blades named after them. The yang sword is "Gan Jiang" while the yin counterpart is "Mo Ye". See WYCQ chapter 4 (*helü neizhuan* 闔閭內傳).

623 Chu 楚 is nowadays Hubei.

smelting and casting flourished during the Qi and Liang periods.[625]

Since the time of Fuxi there are 467 copper mountains.[626]

Nowadays there are basically no more than three types [of copper].

J) Copper Ore Prospection

qí wéi huáng tóng yě
其 為 黃 銅 也 ，

kēng yǒu shū míng
坑 有 殊 名 ，

shān duō zhòng pú
山 多 衆 樸 。

wān shàn fú yǔ
蜿 蟺 扶 輿 ，

yù jī páng bó
鬱 積 磅 礴 。

jié niè cén yíng
巀 嶭 岑 巆 ，

wēi wéi yáo què
崴 嵬 嶢 峬 。

lín bīn lán bān
璘 彬 闌 斑 ，

624 Jin 晉 is nowadays Shanxi.

625 Qi Liang 齊梁 here stands for the Qi dynasty (479-502) and Liang dynasty (502-577) in the Southern Dynasties period. This was a period, during which casting technology in China had many new developments.

626 According to GZ chapter 77 (*dishu* 地数), “There are 467 mountains producing copper / 出銅之山四百六十七山.”

kuàng yàng cuǐ cuò
爌漾璀錯。

xiàn mài xiàn
碯脈見，

hán lù zhuó
函路灼。

niú yǐn pán
牛飲盤，

tiān jǐng luò
天井落。

kuàng wén yì cǎi
礦紋異采，

zhà chún jù bó
乍純遽駁。

xūn miáo shū xìng
燻苗殊性，

yù duàn huán luò
欲斷還絡。

wū jiāo zhuì
烏膠綴，

jīn xīng shuò
金星爍。

sù huā dàn
蔌花淡，

dān shā wò
丹砂渥。

shǔ jié jù tuán
鼠結聚團，

jī	jiāo	sǎn	bó	
雞	燋	散	泊	。
cí	ěr	gāo	yóu	
餈	餌	膏	油	，
yīng	rùn	zhuó	zhuó	
英	潤	濯	濯	。

One of them is yellow copper,[627]

for which mines with different names exist.

the mountains contain a great variety of ores,

which occurs in serpentines, rising spirally

or accumulates to massive blocks.

On the uneven and barren soil of high and steep mountains

iridescent and colourful [outcrops appear],

glittering and full of brightness.

Underground veins show up on the surface

and hidden lodes emit their glow.

The 'drinking buffalo'[628] ascends,

the 'sky well'[629] descends.

The grain of the ore is of different colours,

sometimes pure but suddenly mixed.

Scenting[630] veinlets are of varying nature,

---

627 *Huangtong* 黃銅 does not mean brass in this context but pure copper procured by the conventional pyrometallurgical methods.

628 *Niuyin* 牛飲 supposably stands for an inclines shaft following a deposit in a similar angle as the neck of a buffalo drinking at a water hole. See DNKCTL, 3a.

629 *Tianjing* 天井 may be a vertical shaft, through which a miner can see the sky from underground. See DNKCTL, 3a.

sometimes break off, but are then connected again.
Studded with dark, glue[-like spots][631]
and with golden stars sparkling,[632]
like a light yellow flower,
or like dark red cinnabar,[633]
similar to mice forming a group when gathering,
or similar to chicken dispersing when scared,
resembling greasy and oily rice cakes,
shining, glossy and bright.

K) Copper Mining

sù	yán	yáng	ér	cuì	jiě		
宿	炎	煬	而	脆	解	，	
fēn	jī	jué	ér	qiǎo	zhuó		
紛	刉	劂	而	巧	斲	。	
pī	kàng	hōng	bó	làng	zhī	chuí	
批	亢	轟	博	浪	之	椎	，
xiàn	jiān	dòng	hùn	dùn	zhī	záo	
陷	堅	洞	混	沌	之	鑿	。
yán	yún	yù	qǐ	ér	fù	zhuì	
巖	雲	欲	起	而	復	墜	，

---

630 *Xun* 燻 has probably the same meaning as *xun* 熏. It should be related to the veinlets although it is unclear what phenomenon is meant.

631 *Wujiao* 烏膠 should be CuO. For a more detailed discussion of these descriptions of ores, see chapter II.4b of this thesis.

632 *Jinxing shuo* 金星爍 should refer to CuFeS2.

633 *Suhua* 蔌花 and *dansha* 丹砂, this description may stand stand for Cu2S.

shí huǒ bù chuī ér zī yuè

石火不吹而自躍。

páng páng chí tíng

磅磅馳霆，

bō bō sǎ báo

剝剝灑雹。

qiū shì yán ěr ér jí dùn

丘示掩耳而疾遁，

mù kè pěng xīn ér sǒng è

木客捧心而竦愕。

dǎn hán yě fú zhī kuí wǎng

膽寒野伏之夔罔，

hún chǐ ní pán zhī lóng huò

魂褫泥蟠之龍蠖。

liáo hū xiū suì

繚乎倏隧，

yǒu hū yōu hè

黝乎幽壑。

qián kè páng xiā

潛匼旁呀，

yīn kuǎn xié què

陰窾斜郤。

gòng gōng chù bù zhōu ér dì wéi duàn

共工觸不周而地維斷，

shén yǔ pì yī què ér lóng mén tuò
神禹闢伊闕而龍門拓。

lí shān bǎi rèn zhī xià chuān
驪山百仞之下穿，

kūn míng wàn fū zhī xié zuò
昆明萬夫之偕作，

céng wèi pì qí gōng yòng zhī bó yě
曾未媲其功用之博也。

[Heated] by strong fire overnight, [the rock] becomes brittle and splits
and by using numerous chisels and cutters it is skilfully chopped into pieces.
[Miners] attack the rifts,[634]
pounding like the hammer at Bolang[635]
and they tackle the solid [rock]
piercing through like the chisel into Hundun.[636]

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634 *Pikang* 批亢 means "to beat the crucial part", see SJ chapter 65 (*sunzi wuqi liezhuan* 孫子吳起列傳).

635 *Bolang zhi chui* 博浪之椎: Zhang Liang 張良 wanted to kill Qin Shihuang 秦始皇 in Bolang 博浪, Henan, with a giant iron hammer. See SJ chapter 55 (*liuhou shijia* 留侯世家).

636 *Hundun zhi zao* 混沌之鑿: According to a legend, there was an emperor of the central regions who had no openings in his head for his sensory organs and whose name was Hundun. The emperor of the north and the south came for a visit and wanted to help him by opening wholes in his head. After they had used a chisel to beat seven holes, Hundun died. See ZZ chapter (*neipian, ying diwang* 應帝王內篇).

The smoke in the rocks, though aspiring to rise up, sinks down again
and the fire sparks, though not blown, jump by themselves.
"Bong, bong"[637] rolls the thunder,
"bak, bak"[638] crackles the hail.
The mountain spirits[639] cover their ears and escape hastily
and the forest spectres[640] grasp their hearts, scared and in deep fear.
Frozen gets the courage of the Kui and Wang[641] crouching in the wild
and absconding is the soul from the dragons and worms coiling in the mud.

How winding are the long tunnels
and how sinister are the deep ravines!
Hidden caves are opening on the sides
and dark pits are forming inclined holes.
Gong Gong smashing the Buzhou mountain by which the

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637 *Pang* 磅 stands onomatopoetic for the thunder and thus for the beating of the rock in the mountain. The pronunciation of this character may have been closer to the modern Cantonese pronunciation "bong" at that time.

638 *Bo* 剝 stands onomatopoetic for the hail and thus for the falling pieces of ore and rock. The pronunciation of this character may have been closer to the pronunciation "pak", which was identified for the time of the Tang Dynasty, see Stimson (1976), p. 11, or to the modern Cantonese pronunciation "bok".

639 *Qiushi* 丘示: This word cannot be traced. Probably it describes a kind of ghost, because *qiu* can mean grave hill and *shi* can stand for something that appears around it. This view could be supported by the occasional opinion, that mining disturbs the peace of the dead. Probably also just mountain spirits as natural deities.

640 *Muke* 木客, Hua Jueming interprets this as "woodcutters". See Hua Jueming (1997), p. 565. It is probably more likely that either parallel to the first part of the sentence another kind of mountain or forest ghosts are meant or "wild people" not involved in mining, that live in the forest.

641 Kuiwang 夔罔 is the same with 夔魍, which means Kui 夔 and Wangliang 魍魉, both are monsters living in the forests. See HYDCD, vol. 3, p. 1206.

earthholding ropes were severed,[642]

the divine Yu breaking through Yique[643] by which Longmen[644] was opened,

the digging down at Li Mountain[645] to [a depth of] eight ren

and the cooperation of ten thousand men at Kunming Lake:[646]

none of those can ever compare with the great power of mining.

L) Copper Smelting

dài	qí	lóng	kuì	qí	
逮	其	籠	簣	齊	，
běn	chā	jù			
畚	臿	具	，		
zhuān	zhū	hǔ	jué		
專	諸	虎	攫	，	

[642] Gong Gong 共工 is a Chinese water god who is responsible for the great floods. In Chinese mythology, Gong Gong was ashamed that he lost the fight with Zhu Rong 祝融 to claim the throne of Heaven and in a fit of rage he smashed his head against Buzhou Mountain 不周山, a pillar holding up the sky. The pillar suffered great damage and caused the sky to tilt towards the northwest and the earth to shift to the southeast. This created the tilt of the earth and explains the phenomenon that sun, moon, and stars move towards the northwest, and that rivers in China flow south-eastward. See HNZ chapter 3 (*tianwen xun* 天文訓).

[643] Yique 伊闕 is the name of a place south of Luoyang. *Que* 闕 means gate. Two mountains face each other like an opening gate. According to the legend, Yu broke the mountain to dredge the flood.

[644] Longmen 龍門, lit. Dragon Gate, is the name of a mountain to the south of Luoyang. See HS chapter 29 (*gouxu zhi* 溝洫志).

[645] Lishan 驪山 is the grave mountain of Qin Shihuang. See SJ chapter 6 (*Qinshihuang benji* 秦始皇本紀).

[646] Kunming 昆明 is a lake in Shaanxi during the Han Dynasty. It was enlarged during the reign of Han Wudi (141-87 BC). See HS chapter 6 (*wudi ji* 武帝紀).

mèng bēn shǐ fù
孟賁豕負。

xǐ duī fù yú píng lù
徙堆阜於平陸，

chù cén lóu yú lú bù
矗岑樓於爐步。

xī tàn zhōu rào
熺炭周繞，

kǎo xīn huán fù
藁薪環附。

ruò wàng ér liáo
若望而燎，

ruò chéng ér jù
若城而炬。

shǐ shù yùn yú bì fāng
始束緼於畢方，

xuán gǔ bài yú biāo nù
旋鼓鞴於熛怒。

biān huǒ niú ér tū zǒu
鞭火牛而突走，

qí zhú lóng ér téng wù
騎燭龍而騰騖。

zhàn liè quē pī lì yú yàn tún
戰列缺霹靂於焱庉，

wǔ píng yì fēng lóng yú yān wù
舞屏翳豐隆於煙霧。

yáng niǎo duó yào
陽烏奪耀，

yíng huò xùn dù
熒惑遜度。

shí bèng suǐ
石 迸 髓 ，

zhuó liú rǔ
汋 流 乳 ，

jiāng suǒ róng
江 鏁 融 ，

qí gāo zhù
臍 膏 注 。

gòu zài liàn ér cū zhě xiāo
銗 再 鍊 而 麤 者 消 ，

zhāo fù pēng ér jīng zhě jù
鈲 復 烹 而 精 者 聚

bài shāo ér shàn liū qīng
排 燒 而 汕 溜 傾 ，

chuī fú ér fān kē lù
吹 拂 而 飜 窠 露 。

lì gù kǒng yīn
利 固 孔 殷 ，

lì yì liáng kǔ
力 亦 良 苦 。

wéi bǐ quán jǐng
唯 彼 泉 井 ，

táo shā kě zhù
淘 沙 可 鑄 。

When the baskets and hampers are ready
and the shovels and spades are prepared,
then [the miners] grab [ore] like Zhuan Zhu[647] [as fierce as] tigers
and they carry [it] like Meng Ben[648] as [strong as] boars.
They shift [it] and pile up hills in the plain,
and they erect high towers in the furnace place.
They put glossy charcoals around
and attach dried firewood all over.
Like a town[649], but burning;
like a city, but set on fire.
First they tie together [a piece of] linen with the Bifang[650] [bird];
later they blow the bellows[651] with fierce blaze.
They whip the fire buffaloes[652] which rush out abruptly

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647 Zhuan Zhu 專諸 (?-515 BC) was an assassin during the Spring and Autumn Period who killed King Liao 僚 of Wu 吳 during a banquet with a small dagger which was hidden in a fish. See SJ chapter 86 (*cike liezhuan* 26 客列傳第二十六刺).

648 Meng Ben 孟賁 was a warrior during the warring states period. See MZ 孟子, chapter *Gongsun Chou shang* 公孫丑上.

649 *Wang* 望 has to be read here as a prefix to the designation "district" (*xian* 縣) when the unit of territorial administration incorporated more than 4,000 registered households, as a town. See Hucker (1985), p. 562, item 7635.

650 Bifang 畢方is a bird in legend, when it appears, fire comes along. Here it probably just stands for fire. See SHJ vol. 2, (*xishan jing* 西山經), chapter 3, "There is a bird here which looks like a crane; it has one foot, scarlet markings on a green background, and a white beak. Its name is the end square. When it sings, it calls its own name: 'Bi-fang.' Wherever it appears, that town will suffer from outbreaks of arson /有鳥焉，其狀如鶴，一足，赤文青質而白喙，名曰畢方。其鳴自叫也，見則其邑有譌火". SHJ / Birrell, p. 25.

651 *Gu* 鼓 is used to replace *bai* 韛, which is a leather bag for bellowing.

And they ride the torch dragons[653] which soar up in a gallop.
[Thus they cause] lightning and thunderbolt to fight in the blasting fire
and Pingyi[654] and Fenglong[655] to swing their weapons in the thick smoke.
The sun bird[656] is deprived of its shining,
and Mars withdraws from his position.

From ore, the marrow is expelled
and from the core, the milk flows out.
The Yangtze River chain-lock[657] was melted
and fat poured out of the navel.[658]
If the ore is smelted repeatedly then its crudeness is diminished,
and if crude copper is heated again then its fineness accumulates.[659]

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652 *Huoniu* 火牛 means "fire buffalo" and refers to a warfare tactic used in a battle, which is to set the tails of buffaloes on fire and to drive them into the enemy lines in order to create chaos. See SJ chapter 82 (*Tian Dan liezhuan* 田單列傳).

653 Zhulong 燭龍, lit. "torch dragon" is a god who can illuminate the whole world by opening his eyes. See SHJ chapter 17 (*dahuang bei jing* 大荒北經).

654 Pingyi 屏翳 is a god of cloud, rain, thunder and wind. See HYDCD, vol. 4, p. 37.

655 Fenglong 豐隆 is a god of thunder. See HNZ chapter 3 (*tianwen xun* 天文訓).

656 Yangwu 陽烏 is the crow with three feet in the sun. See WX *Shudu Fu* 蜀都賦 by Zuo Si 左思.

657 *Jiangsuo* 江鏁 means "river lock" and refers to a story during the time of the Three Kingdoms. Jin wanted to attack Wu, who blocked the Yangtze River with an iron chain. Jin sent a ship loaded with coal and oil, set it on fire and melted the chain. See JS vol. 42 (*Wang Jun liezhuan* 王濬列傳).

658 *Qigao* 臍膏 means "navel fat" and refers to the story of Dong Zhuo 董卓. At the end of the Eastern Han period and the beginning of the Three Kingdoms he was a very hated corrupted official. After his execution, people lit a wick in his navel, which continued to burn from his fat for days. See SGZ, Wei Shu 魏書, chapter 6 (*Dong Zhuo zhuan* 董卓傳).

After blowing the bellows and burning, the liquid copper pours out,
after blowing and fanning, silver is revealed.[660]
The profit doubtlessly is very rich,
but the work is also very hard.
Only [from some] springs and wells,
the washed out sand can [already] be cast.[661]

[659] *Zhao* 鉥 is refined copper. See SYZJ / LQXZ, pp. 177-178. “Then one burns the metal pieces five times in a row for seven days and seven nights. After that one puts them it into the big whirlwind furnace and heats them there for one day and one night, the result is called zhao. Zhao is the copper‘s body which gradually appears after crudeness and dirt have left. /次將碎連燒五火，計七日七夜，又依前動大旋風爐，連烹一晝夜，是謂成鉥。鉥者，麄濁既出，漸見銅體矣.“

[660] *Fan* 飜 is the same as *fan* 翻 and means “to turn.” *Fanke* 飜窠 thus means "turning over the nest.” Silver can be extracted from many copper ores by adding lead. The silver-lead alloy is remelted in a special cave-shaped oven until the lead vaporizes and reveals the pure silver. The expression can thus be read as a name for silver itself. See SYZJ / LQXZ, p. 176. “After yet another while, its colour on one side first changes to a muddy one, this [process] is called kefan (‘turning over the nest‘) /又少頃，其色自一邊先變渾色，是謂窠翻.“

[661] This verse should allude to findings of native copper in alluvial deposits.

M) Copper Soaking

qí	jìn	tóng	yě			
其	浸	銅	也	，		
qiān	shān	xīng	lì			
鈆	山	興	利	，		
shǒu	jiū	zhuàn	gōng			
首	鳩	僝	功	。		
tuī	ér	fàng	zhū			
推	而	放	諸	，		
xiàng	jiē	qǔ	méng			
象	皆	取	蒙	。		
biàn	yǐ	yì	yá	zhī	kǒu	
辨	以	易	牙	之	口	，
dǎn	suí	wèi	ér	bù	tóng	
膽	隨	味	而	不	同	。
qīng	sè	kǔ	yǐ	jū	shàng	
青	澁	苦	以	居	上	，
huáng	tǎn	suān	ér	cì	zhōng	
黃	醓	酸	而	次	中	。
jiàn	yǐ	lí	lóu	zhī	mù	
鑒	以	離	婁	之	目	，
fàn	fú	òu	ér	yì	róng	
泛	浮	漚	而	異	容	。
chì	jiàn	bái	yǐ	wéi	guì	
赤	間	白	以	為	貴	，
zǐ	duó	zhū	ér	fú	yōng	
紫	奪	朱	而	弗	庸	。

bēi zhǎo jì zhū
陂沼既瀦，

gōu suì sī jué
溝遂斯決。

chán zhuó hòng róng
瀺灂澒溶，

gǔ mì piē liè
汩滵潎洌。

tóng què tái zhī yán liù
銅雀台之簷霤，

wàn wǎ jiàn líng ér cóng cóng
萬瓦建瓴而淙淙；

lóng gǔ qú zhī shuǐ dào
龍骨渠之水道，

qiān kuài fēn qí ér jué jué
千澮分畦而潏潏。

liáng shēn qiǎn yǐ shī cáo
量深淺以施槽，

suí shū mì ér zhì zhá
隨疏密而制閘。

lù xù tūn tǔ
陸續吞吐，

chán lián guàn liè
蟬聯貫列。

nǎi pò bù láo zhī fǔ
乃破不轑之釜，

nǎi suì bù shāng zhī qí
乃碎不湘之錡。

rú lín sī bù
如鱗斯布，

rú yì sī qǐ
如 翼 斯 起 。

shù zhī lóng lóng
漱 之 瓏 瓏 ，

jiàn zhī chǐ chǐ
濺 之 齒 齒 。

chén hán jí biǎo lǐ yǐ jù chàng
沉 涵 極 表 裏 以 俱 暢 ，

zhēng niàng qióng rì yè ér bù zhǐ
蒸 釀 窮 日 夜 而 不 止 。

yuán míng xiào qí qiǎo jué
元 冥 効 其 巧 譎 ，

yáng hóu xiàn qí guài guǐ
陽 侯 獻 其 恠 詭 。

biàn shí wéi mò
變 蝕 為 沫 ，

zhuǎn sè wéi suǐ
轉 澁 為 瀡 。

huò jiā xià diàn
或 浹 下 簟 ，

zì níng zhū ruǐ
自 凝 珠 蕊 。

qiě zhuó qiě jiàn
且 濯 且 漸 ，

jìn huà nǎi yǐ
盡 化 乃 已 。

tóu zhī lú chá
投 之 爐 鍤 ，

suì chéng cuì měi
遂 成 粹 美 。

Another one is soaked copper.
Qianshan and Xingli were the first mines to carry out [this method]
successfully,
[their examples] spread to all [directions]
where they were learned and adapted.[662]

Distinction is made with a mouth [like the one of] Yi Ya[663].
Vitriol [water] differs with respect to its taste:
Blue-green, astringent and bitter, these are the best ones,
yellow, juicy[664] and sour, these are next best.
Differentiation is [achieved] with eyes [like the ones] of Li Lou[665].
Foam is floating on the surface with different appearances:
Red intermingling with white, these are held to be the most precious.
Purple dominating over vermilion, these are [also] good to use.

Pools and ponds full of water,
bursting through gutters and channels;
sputtering and gurgling, the water, stretching deep and wide;
flowing fast, with waves beating each other;

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662 *Xiang jie qu meng* 象皆取蒙 is based on Yi Jing 易經, the Meng 蒙 Hexagram, the "Treatise on the Symbolism of the Hexagrams", "[The trigram representing] a mountain, and beneath it that for a spring issuing forth form Mang. The superior man, in accordance with this, strives to be resolute in his conduct and nourishes his virtue / 《象》曰：山下出泉，蒙；君子以果行育德." YJ / Legge, p. 271. The sentence shows the process of teaching and learning.

663 Yi Ya 易牙 is a person who was good at cooking thus had a great sense of taste. See ZZ chapter *xigong shiqi nian* 僖公十七年.

664 *Tan* 醓 is a kind of sour meat sauce. HYDCD, vol. 9, p. 1436.

665 Li Lou 離婁 is a person with extraordinary good eyesight in the legend. See MZ chapter (*Li Lou shang* 離婁上).

[like] the stream of water from the eaves of the Copper-Sparrow-Platform[666],
rushing in the channels formed by ten thousand tiles,
[like] the waterway of the Dragon-Bone-Canal[667],
sputtering in one thousand ditches and distributing to the parterres.
The depth is measured to construct grooves,
and according to the distance sluice gates are built.
Swallowing and spouting in succession,
stretching along and arranged in good order.

Then pans not used for frying anymore are smashed
and pots not used for cooking[668] anymore are broken.
Spread there like [fish] scales
and protruding like flippers[669].
they are rinsed "long-long"
and splashed "chi-chi".
Soaked and immersed, they are penetrated from outside to inside;
incessantly steaming and fermenting, day and night.
Yuanming[670] exerts his fantastic skills,

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666 Tongque Tai 銅雀台, lit. "Copper Sparrow Platform" was a palace built by Cao Cao 曹操 in 210 in Linzhang county 臨漳縣, Hebei. See SGZ, *Wei Shu* 魏書 chapter 1 (*wudi ji* 武帝紀).

667 Longgu Qu 龍骨渠 is another word for the Longshou Qu 龍首渠, a canal dredged during the reign of Han Wudi 漢武帝. A "Dragon bone" was found during the construction works from which it had its name. See HS chapter 29 (*gouxu zhi 9* 溝洫志第九).

668 *Shang* 湘 is used to replace the character *shang* 鬺, which means "to cook."

669 *Yi* 翼 can mean "wings" or "fish flippers", both readings are imaginable here.

670 Yuanming 元冥 is the name of a water god. See SHJ chapter 8 (*haiwai bei jing* 海外北經).

and Yanghou[671] contributes his extraordinary genius.
[Iron] is corroded and changed into foam,
and the rough taste turns into a smooth one.[672]
If seeping through a bamboo mat,
all by itself [copper] coagulates to beads and balls.[673]
Washing and imbueing [continues]
until each and everything has been transformed.
One throws it into the furnace and [blow] the bellows,
the result is pure and beautiful [copper].

N) Copper Leaching

qí	lín	tóng	yě	
其	淋	銅	也	，
jīng	shǐ	cén	shuǐ	
經	始	岑	水	，
yǐ	dài	yǒng	xīng	
以	逮	永	興	。
dì	qì	suǒ	yù	
地	氣	所	育	，
tā	kě	lèi	chēng	
它	可	類	稱	。

671 Yanghou 陽侯 is a god of waves. See ZGC chapter 27 (*Hance er* 韓策二).

672 According to Hua Jueming (1997), p.569 *sui* 瀡 is the same with *xiu* 滫, which means the water after washing rice. It is probably better to read it as *sui* 瀡, which means a condiment that can make food taste smoother. See LJ chapter 12 (*neize* 內則).

673 *Rui* 蕊 means “to clump.” Here it means, that the newly formed copper pieces gather on the mat, and look like little pearls or balls.

tǔ bào dǎn ér qián fā
土抱膽而潛發，

wū suǒ táo ér jí chéng
屋索綯而亟乘。

pōu màn yǎn
剖曼衍，

gōng líng céng
攻崚嶒。

fú zhí qù
浮埴去，

jiān rǎng chéng
堅壤呈。

dé jī zǐ zhī pēi huáng
得雞子之肧黃，

zhī tǔ hóu zhī suǒ níng
知土銗之所凝。

niǎn yùn sè yú jiè xī
輦運塞於介蹊，

è jī gāo yú xiū yíng
[illegible]積高於脩楹。

rì yù jiǔ ér zī lì
日愈久而滋力，

fán jì shēng ér xì lǔn
礬既生而細碖。

shì shè chāo pén yún luò yǐ jǐ
是設抄盆[illegible]絡以庋，

shì zhì pì cáo zhú lóng2 yǐ shī
是築甓槽竹龍以釃。

sǎn mín yè ér zhōng pū
散鈱葉而中鋪，

wò hóu yè ér xià zì
沃銗液而下漬。

yǒng bào wèng yǐ chán yuán
勇抱甕以潺湲，

xún fān piáo ér pēng bì
馴飜瓢而滂濞。

fēn yàn dàn yú zī shéng
分醼淡於淄澠，

bié qīng zhuó yú jīng wèi
別清濁於涇渭。

qí shèn xiè zhī shēng
其滲瀉之聲，

zé zāo qiū yā jiǔ yú bù
則糟丘壓酒於步

bīng zhī chú
兵之厨；

qí zhuǎn yǐn zhī shì
其轉引之勢，

zé kě wū chuán lòu yú qiè
則渴烏傳漏於挈

hú zhī shì
壺之氏。

zuǒ yì yòu zhù
左挹右注，

xún huán bù jié
循環不竭。

zhòu jiān xī gài
晝湛夕溉，

xūn rǎn xī hē
薰染翕欱。

huàn chéng hán nuǎn zào shī bù
幻 成 寒 煖 燥 濕 不

yí zhī tǐ
移 之 體 ，

yí dāo guī zhī diǎn tiě
疑 刀 圭 之 點 鐵 。

Yet another one is leaching copper,
which was first applied in Censhui
and then reached Yongxing.

That what is nourished by the Qi of the earth,[674]
can be compared by analogy.
The earth embracing vitriol grows it in the hidden
This is like the roofs for which one twists ropes and hastes up.[675]
Dissecting is carried out on a large scale
and steep and high mountains are attacked.
The surface dust is removed so that the solid soil appears.
If one gets the embryonic yolk of the hen’s egg,
then one knows the place where the eart ores coagulate.

---

674 *Diqi* 地氣, see LJ chapter 6, (*yueling* 月令), "[in this month] the vapours of heaven descend and those of the earth ascend. Heaven and earth are in harmonious co-operation. All plants bud and grow / 天氣下降，地氣上騰，天地和同，草木萌動." LJ / Legge, p. 255.

675 This sentence is based on the poem Qiyue 七月 in the SJG chapter (*bin feng* 豳风), "The reeds we'll gather while we have the light, and firmly twist them into ropes at night. Up on the roofs we'll haste with these in hand – soon will the fields our time again demand. / 晝爾于茅，宵爾索綯，亟其乘屋，其始播百穀", SHG / Legge, vol. 2, p. 183.

Transport Carriages block the small paths,[676]
and the mounds piled up loftier than high pillars.
The more days pass by the stronger its force is nourished,[677]
Then alum appears and tumbles down as small stones.
Container basins and bamboo skin nets are prepared to load [it] on them,
tiled grooves and bamboo baskets are set up to filtrate [the water].
Then leave-shaped iron chips are spread into [the grooves],
and after irrigating them with ore-bearing liquid, they are soaked through.
The water flows when jars are forcefully lifted
and it splashes when the gourd ladles are gently turned.
Like distinguishing between the strong and the light [tasting] water in the rivers Zi and Sheng,[678]
and like differentiating between the clear and muddy water in the rivers Jing and Wei.[679]
With a sound of seeping and pouring
like when wine is squeezed out of a heap of fermented rice in the infantry kitchen[680],

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676 *Xi* 蹊 is a path or a road in the mountains. See MZ chapter (*jinxin xia* 盡心下).

677 Probably vitriol earth of better quality was regarded as „old" vitriol earth as a part of the Chinese idea of minerals growing in the earth like plants. See chapters V.3 and VIII.1b of this thesis.

678 Zi 淄 and Sheng 澠 are two rivers in Shandong. They are said to have different tastes and if mixed, it is difficult to distinguish. See ZGC chapter 13 (*Qice liu* 齊策六).

679 Jing 涇 and Wei 渭 are two rivers in Shaanxi. In the Jing the water is clear and in the Wei it is rather muddy. See SJG chapter *beifeng* 邶風, poem *Gufeng* 谷風, "The muddiness of the King appears from the Wei, but its bottom may be seen about the islets / 以渭濁，湜湜其沚. SHG /Legge, vol. 4, p. 56.

680 *Bubing zhi chu* 步兵之厨 stands for a wine making place. In the story of Ruan Ji 阮籍 he pursued the position of Bubing Xiaowei 步兵校尉 (Infantry Commander) just because in his kitchen there would then be plenty of wine. See SGZ vol. 21, (*Wei shu* 魏書) Ruan Ji.

and with arrangements of diverting and conducting
like when the Waterholding Official uses the "Thirsty Raven"[681] to feed the water clock,
on the left side, water is ladled out and poured on the right side
in perpetual cycles without end;
seeping and watering through days and nights;
getting permeated and imbued until united.
Magically an object is completed, which does not change by cold, heat, dryness or humidity,
as if iron were touched [and turned into gold] by a powerful essence.[682]

O) Transportation and Organization

ruò	nǎi	kuàng	kè	dēng	
若	乃	卝	課	登	，
gāng	chéng	cù			
綱	程	促	。		
tiě	wǎng	tóng	lái		
鐵	往	銅	來	，	
xī	zhì	qiān	xù		
錫	至	鉛	續	。	

681 *Kewu* 渴烏, lit. "thirsty raven", and *qiehu* 挈壺 or "water holder", see SS chapter 23, (*lüli zhi san* 律歷志三). Qiehu is an official title which is in charge of informing time. Kewu is his working equipment, a curved pipe, which is a part of a water clock. For further details See HHS, chapter 78 (*huanzhe zhuan* 宦者傳), Zhang Rang 張讓.

682 Daogui 刀圭 is a precious and magical medicine used by daoists. See HYDCD, vol. 2, p. 546.

chuān fú zhú lú zhī xián wěi
川浮舳艫之銜尾，

lù zǒu chē dàn zhī qiǎng zhǔ
陸走車擔之繈屬。

chū lǐng qiáo
出嶺嶠，

xià jīng shǔ
下荊蜀。

jué péng lí dòng tíng ér xīng chí
絕彭蠡洞庭而星馳，

sù zhòng huái dà jiāng ér diàn zhú
泝重淮大江而電逐。

sì qū huán fǔ
四趍圜府，

rú fú yǒu gǔ
如輻有轂。

yīn lín xuān kē
殷轔軒磕，

zè lì fù lù
崱屴複陸。

dùn zhī lián chéng
頓之連城，

zhù zhī liè wū
貯之列屋。

hēi yún tuí shān ér luàn wěi
黑雲隤山而亂委，

xióng bào hān xiā ér qǐ fú
熊豹谽谺而起伏。

gài bú dài xiāo fēi lián
蓋 不 待 銷 飛 廉 、

pī qú tán
鉟 瞿 曇 ，

ér zhōng guān zhī yòng zú
而 鐘 官 之 用 足 。

Thereafter mining taxes are levied
and convoy transports are expedited.
Iron and copper are coming and going,
and tin and lead are arriving and departing.
On the rivers, bows and sterns[683] [of ships] are floating in close succession
and on overland [routes], carts and carriers are lined up[684] like a rope.
Out they go of the Lingqiao Mountains[685], descending to Jing and Shu,
across the Poyang[686] and the Dongting Lakes speeding like falling stars
and upstream the Huai and Yangtze Rivers chasing like lightings.
From all four directions they are heading for the heavenly treasury[687]
like spokes to the hub.

---

683 *Zhu* 舳 is a ship's bow, *lu* 艫 is a ship's stern. *Zhulu* means ships lined up end to end forming a chain. See HYDCD, vol. 9, p. 6.

684 *Qiangzhu* 繈屬 means "in a row" or "continuous". See HYDCD, vol. 9, p. 1023.

685 Lingqiao 嶺嶠 refers to the region of the Wuling 五嶺 mountain range which divides the Yangtze and Pearl River drainage basins from each other. See HYDCD, vol. 3, p. 871.

686 Pengli 彭蠡 is the Poyang Lake in Jiangxi.

687 *Yuanfu* 圜府 was an institution in charge of currency and finance. See HYDCD, vol. 3, p. 670.

Roaring noise[688] of many wheels
in ranges of high and steep mountains.[689]

[Metal] is arranged in the shape of a city wall
and it is stored forming rows of houses.
[Between] black clouds in rugged mountains,
[the road] winds and crooks disorderly,
and [among] bears and leopards in empty valleys,
[the path] rises and descends.
Therefor there is no need to melt down [copper] statues of the Feilian[690]
nor of Sakyamuni,[691]
since there is enough to be used by the Director of Minters.[692]

P) Minting Technology

yú	shì					
於	是	，				
zhù	qián	shǐ	kǎo	qí	huì	
鑄	錢	使	攷	其	會	，
biàn	tóng	lìng	dì	qí	pǐn	
辨	銅	令	第	其	品	。

688 *Yinlin* 殷轔 stands for the sound of carriages. See HYDCD, vol. 6, p. 1481.

689 *Zeli* 崱屴 means “tall and steep mountain peak”. See HYDCD, vol. 3, p. 853.

690 Feilian 飛廉 is a statue made of copper during the reign of Han Wudi 漢武帝. See SFHT chapter *guan* 觀.

691 Qutan 瞿曇 is the family name of Sakyamuni in Chinese, see HYDCD, vol. 7, p. 1261. Here it refers to Buddha statues made of copper in general.

692 *Zhongguan* 鐘官 is an official title and means “Director of Minters”. See Hucker (1985), p. 191, item 1575.

dīng fū jié zuò
丁夫竭作，

jiàng shī huān fèn
匠師讙奮。

méi tū zhěng jié
煤突整潔，

tàn hù chōng rèn
炭戶充牣。

gǔ liǎng yí zhī yuè ér dà bǒ
鼓兩儀之籥而大播，

yì liù dīng zhī gōng ér dié yùn
役六丁之工而迭運。

zhù róng zuò
祝融作，

nǚ wā jìn
女媧進。

yī shān tāo shēng hǎi mén zhī wēi bō
一煽濤生海門之微波，

zài shān rì tǔ fú sāng zhī dié yùn
再煽日吐扶桑之疊暈，

sān shān hōng zhāo xiá ér làn zhào
三煽烘朝霞而爛照，

sì shān xiōng zhūn léi ér yù zhèn
四煽洶屯雷而欲震。

zhāng hè zé zhī huī yàn
張格澤之輝燄，

bèng chán qiǎng zhī máng rùn
迸攙搶之芒潤。

kuā fù jí zhī
夸父即之，

hàn fān jiāng ér yē
汗翻漿而暍；

hé bó wàng zhī
河伯望之，

tóng xuàn huā ér shùn
瞳眩花而瞬。

chéng chè bù xiáo
澄澈不殽，

tōng míng wú jìn
通明無燼。

hēi zhuó zhī qì jié ér huáng qì cì
黑濁之氣竭而黃氣次，

huáng bái zhī qì jié ér qīng qì yìng
黃白之氣竭而青氣應。

yè yuán xiè yú dōu sháo
液爰瀉於兜杓，

xiá suì míng yú mú yìn
匣遂明於模印。

juē zhī luò luò
撅之落落，

guàn zhī lín lín
貫之磷磷。

cuō zhī yǐ fēng chē zhī péng yà
磋之以風車之輣軋，

lù zhī yĭ shuĭ lún zhī pēng yĭn

轆 之 以 水 輪 之 砰 隱 。

zēng wăng juān shì

繒 網 涓 拭 ，

gŭ hé mó shŭn

蠱 覈 摩 揗 。

ròu hăo zhōu guō

肉 好 周 郭 ，

jiān zé jīng jĭn

堅 澤 精 緊 。

wén jìn yín gōu

文 勁 銀 鈎 ，

sè yíng yù tián

色 瑩 玉 填 。

jì guā gòu yĭ mó guāng

既 刮 垢 以 磨 光 ，

shĭ jié mín ér jiù zhŭn

始 結 緡 而 就 准 。

jìn dōng mén zhī òu má

盡 東 門 之 漚 麻 ，

bù zú yĭ wéi qí guàn yĭn

不 足 以 為 其 貫 引 。

At that time

the coinage commissioner inspects the alloy's colour,[693]

the director of grading and sorting raw copper evaluates its quality,

the workmen labour exhaustingly,

and the craftsmen exert themselves vigorously.

---

693 *Hui* 會 is used to replace the character 繪 it stands for the mixed colours of metals and alloys.

The sooth chimneys are neat and clean,

and the charcoal-producing households plentiful and abundant.[694]

There is huge agitation by blowing the 'bellows of the Two Powers',[695]

and “operation in change and circulation”[696] is carried out employing the efforts of the [gods of the] six combinations.[697]

Zhu Rong[698] acts

and Nüwa promotes.

The first blow-a big wave is created by the light ripples at the entrance of the sea;

again a blow-the sun is disclosed by the multi-layered aurora at the Fusang tree.[699]

The third blow heats up the rosy clouds of dawn and gives them the full brightness,

and the fourth blow incites the thunder until it is about to tremble.

Displayed are the brilliant flumes of the Heze [star],[700]

and spilled are the glossy rays of the Chanqiang [comet].[701]

---

694 *Ren* 牣 means “full” or “abundant”.

695 *Yue* 籥 is a bamboo device for air blowing.

696 *Dieyun* 迭運 means “operation in change and circulation”. This probably refers to a certain pattern of labour organization among the workers.

697 *Liuding* 六丁 stands for the six gods in Daoism. See HYDCD, vol. 2, p. 24.

698 Zhu Rong 祝融 is a god of fire and the ruler of the southern hemisphere in ancient Chinese mythology. See GY, chapter 16 (*Zheng Yu* 鄭語).

699 Fusang 扶桑 in Chinese mythology refers to a divine tree in the East, from where the sun rises. See SHJ, chapter 9 (*haiwai dong jing* 海外東經).

700 Heze 格澤 is the name of a star, which looks like fire. See SJ chapter 27 (*tianguan shu* 天官書).

701 Chanqiang 攙搶 is the name of a comet.

If Kuafu[702] approached [the fire], [his] sweat would turn viscous and he would suffer a heat stroke,
if Hebo[703] looked into it, his pupils would become dazzled and he would blink.
Transparent throughout and spotless,
thoroughly bright and without ashes!
When the black and turbid smoke is exhausted, yellow smoke comes next,
and when the yellow and white smoke is exhausted, blue-green smoke follows.[704]
Then the melt flows swiftly into the casting ladle
and the sand moulds are prepared through the imprint of the matrix [coins].[705]
[The coin trees] are broken up-"luo luo"
and [the coins] are pierced [on a stick]-"lin lin".
With the squeaking noise of a wind-driven wheel, they are polished;
with the crunching sound of a water wheel they are rolled.
[Then] they are wiped clean with a silk net and scrubbed with grain chaff.
Margin and hole [form a] complete contour
firm, lustrous, fine and tight.
The legend is vigorous like silver hook [calligraphy],[706]

---

702 Kuafu 夸父 is a giant in Chinese mythology who wished to capture the sun. See LIZ chapter 5 (*tangwen* 湯問) and SHJ chapter (*haiwai bei jing* 海外北經).

703 Hebo 河伯 is a river god. See *Zhuangzi*, chap. Qiushui 秋水.

704 This sentence is from ZL chapter 6 (*dongguan kaogong ji* 冬官考工記), Zhuo Shi 卓氏, "The circumstances of smelting metal: In the case of tin alloys, when the black and turbid smoke is exhausted, yellow and white smokes come next, when the yellow and white smoke is exhausted, blue-green and white smokes come next, when the blue-green and white smokes are exhausted, [purely] blue-green smoke comes. Then [the metal] can be cast. / 凡鑄金之狀；金與錫，黑濁之氣竭，黃白次之，黃白之氣竭，青白次之。青白之氣竭，青氣次之，然後可鑄也。"

705 This refers to the application of the sand casting method in the Song mints. Moulds where shaped by the imprint of a matrix coin into a special mixture of wet sand and other ingredients. After that, two sand moulds were attached to each other to form a complete foundry box for both sides of the coin.

the colour brilliant like jade.

Only after the dirt has been scraped off and they have been polished smooth,

are they stringed and brought to the steelyard.

All the ret flax at the East Gate[707] is used up,

But this is still not sufficient for making all the [required] strings.

Q) Monetary Policy

bǎi	lì	gào	gōng					
百	吏	告	功	，				
sān	guān	dòng	sè					
三	官	動	色	。				
nǎi	dū	yùn	sōu					
乃	督	餫	艘	，				
nǎi	shū	wáng	guó					
乃	輸	王	國	。				
bǎn	cáo	jī	qí	yíng	xū	zhī	shù	
版	曹	稽	其	贏	虛	之	數	，
qǐ	bù	chéng	qí	jīng	cū	zhī	jì	
起	部	程	其	精	觕	之	績	。
jǐn	nèi	fǔ	zhī	dēng	chǔ			
謹	內	府	之	登	儲	，		
yǎn	wài	tǎng	zhī	zhuāng	jī			
衍	外	帑	之	樁	積	。		

706 *Yingou* 銀鉤 or "silver hook" stand for a calligraphy style with forceful strokes but also for the calligraphy on the coins in general.

707 *Dongmen zhi ouma* 東門之漚麻, based on a sentence from the poem Dongmen Zhi Chi 東門之池 in SJG chapter *chen feng* 陳風, "The moat at the east gate is fit to steep hemp in. 東門之池，可以漚麻". SHG / Legge, vol. 4, p. 208. Hemp is soaked in water for fermenting.

tiān zǐ shǒu zhī yǐ gōng jiǎn
天子守之以恭儉，

zhǒng zǎi lǐ zhī yǐ jūn jié
冢宰理之以均節。

yǔ wǔ zhū kāi yuán ér bìng xíng
與五銖開元而並行，

yì huáng bǎng zǐ biāo zhī sī zhí
異黃榜紫標之私殖。

jīn gōng shuò zhī zé yǒu jìn
金工鑠之則有禁，

mán bó xiè zhī zé yǒu pì
蠻舶洩之則有辟。

yí jīng shī guàn xiǔ ér mò jiào
宜京師貫朽而莫校，

tiān xià cáng qiǎng ér shān zé yě
天下藏鏹而山則也。

qí huò yòng qǔ lù pí
其或用取鹿皮，

zhì cān fēi qián
制參飛錢。

tōng wù zhī biàn
通物之變，

fú shí zhī piān
扶時之偏。

yì běn yú qīng zhòng xiāng jì
亦本於輕重相濟，

zǐ mǔ zhī xiāng quán
子母之相權。

zhì	lùn	zhí	cái					
至	論	殖	財	，				
mò	rú	zé	shǐ					
莫	如	擇	使	。				
yǒu	guǎn	zhòng	zé	cáng	fù	yú	guó	
有	管	仲	則	藏	富	於	國	，
dé	liú	yàn	zé	qián	liú	yú	dì	
得	劉	晏	則	錢	流	於	地	。

One hundred clerks report about meritorious services,
and the Holders of the Three Offices'[708] [face] colour [shows] action.
They supervise the transport ships
and they convey [the coins all over] the royal state.
The Board of Revenue[709] checks the figures of gains and losses
and the Board of Works[710] examines the degrees of roughness and fineness.
The growth of the imperial treasure[711] is taken care of,
and the [increase of] stock in the national treasury[712] is promoted.
The Son of Heaven preserves it with respect and frugality
and the Chancellor[713] handles it with considerateness and integrity.

---

[708] *Sanguan* 三官 are the three officials in charge of minting under the Han Dynasty, namely *Junshu* 均輸 (Office of Tax Substitutes), *Zhongguan* 鍾官 (Director of Minters) and *Bantongling* 辨銅令 (Director of Copper Management). See Shi Ji, chap. 30, Pingzhun Shu平准書 and Hucker (1985), p. 202, item 1787; p. 191, item 1575.

[709] *Bancao* 版曹 refers to the Ministry of Revenue. See Hucker (1985), p. 363, item 4418.

[710] *Qibu* 起部 refers to the Ministry of Works. See Hucker (1985), p. 136, item 635.

[711] *Neifu*内府 is the Palace Treasury. See Hucker (1985), p. 345, item 4175.

[712] *Zhuangji* 樁積 means "storehouse". See HYDCD, vol. 4, p. 1237.

[713] *Zhongzai* 冢宰 means "Minister of State". See Hucker (1985), pp. 194-195, item 1632.

[The newly cast coins] are circulating together with Wuzhu and Kaiyuan [coins].
[This is] different from the selfish [accumulation] of fortune [in the story] "Yellow Mark and Purple Label".[714]
For melting down [the coins] by metal craftsmen, there are prohibitions
and for their export on southern sea ships, there are punishments.[715]
It appears, that in the capital coin strings rot without anybody caring for it
[and that,] all-under-heaven the cash strings stored resemble a mountain.

That sometimes [instead of them] deer skin[716] was used [as a currency],
and that sometimes 'flying cash'[717] is mixed in
to master the changes of the world
and to brace the oscillations of time
is based on [the policy], that the light and the heavy should support each other
and that the mother and the child should be in balance.
If it comes to the theme of increasing wealth
then nothing equals the choice of the right officials.

---

714 *Huangbang* 黄榜 and *Zibiao* 紫標 refer to Xiao Hong's 蕭宏 story of hoarding privately big amounts of coins. See NS chapter 51 (*Linchuan jinghuiwang Hong zhuan* 臨川靜惠王宏傳), "Hong loves cash. When he gathers one million coins together he labels them with one yellow mark; then he puts always ten million coins together into one storehouse and marks it with one purple label. / 宏性愛錢，百萬一聚，黄榜標之；千萬一庫，懸一紫標。如此三十餘間".

715 During the Song period there were various prohibitions concerning mainly the melting down, outflow and hoarding of copper cash. For more information on this Topic see Wang Shengduo (2004) p. 75-99.

716 *Lupi* 鹿皮, refers to the deerskin currency issued in 119 BC under the Western Han Dynasty. The one *chi* long and wide, square-shaped deerskin was used as equivalent for 400,000 coins. See HS chapter 24 (*shihuo zhi xia* 食貨志下). It can be regarded as the earliest origin of paper money in China.

717 *Feiqian* 飛錢, or "Flying Cash", was a name for a paper currency during the Tang Dynasty. See XTS chapter 44 (*shihuo zhi si* 食貨志四).

When there was a Guan Zhong[718], then the treasure grew rich in the state
and when a Liu Yan[719] was appointed, then cash coins were so many, that they even flowed on the ground.

R) Morale

yán wèi bì
言 未 畢 ，

kè yǒu zài páng yǎ rán ér
客 有 在 旁 啞 然 而

xiào yuē
笑 曰 ：

zǐ lái zì pó
“ 子 來 自 番 ，

zhī quán zé xiáng
知 泉 則 詳 。

kǎn wā nán yǔ hū hǎi shuǐ
坎 蛙 難 語 乎 海 水 ，

xī jī wèi kuī hū tiān guāng
醯 雞 未 窺 乎 天 光 。

dú bù wén fù yǐ nán miàn
獨 不 聞 負 扆 南 面 ，

718 Guan Zhong 管仲, (c. 720-645 BC) was a politician and statesman of the State of Qi during the Spring and Autumn Period. Under Guan's guidance important economic reforms were introduced. He created a uniform tax system and employed the power of the state to strengthen the production of Salt and Iron. See SJ chapter 62 (*Guan Yan liezhuan* 管晏列傳).

719 Liu Yan 劉晏, (715/16 -780) served briefly as a chancellor during the Tang Dynasty and is known for his reforms in the salt monopoly system. See JTS chapter 123 (*liezhuan 73* 列傳第七十三).

yùn yǎng yà zhī jūn ér gǔ
運坱圠之鈞而鼓

sì fāng zhě hū
四方者乎？

dàng bā guà
盪八卦，

fàn jiǔ zhāng
範九章。

yáng guān jū
颺關雎，

bō wǒ jiāng
播我將。

róng shù pǐn yú dào dé zhī tuó
融庶品於道德之橐，

liǎn zhòng bǎo yú jùn yì zhī chǎng
斂眾寶於俊乂之場。

mó ér bù lìn zhě
磨而不磷者，

bù zài tái shěng
布在臺省；

dòng zhī sī hé zhě
動之斯和者，

zuò zhū miào táng
坐諸廟堂。

xuán qián zhuǎn kūn
旋乾轉坤，

hé yīn pì yáng
闔陰闢陽。

táo táng yě yú
陶唐冶虞，

guī zhōu jǔ shāng
規周矩商。

lǐ yuè níng sú
禮樂凝俗，

yì yǔ ér liáng
易窳而良。

rén yì zhù rén
仁義鑄人，

gé pǐ ér zāng
革否而臧。

tái jiē yǐ píng
泰階以平，

tiān bù yǐ kāng
天步以康。

qián xīng làn hū chóng huī
前星爛乎重暉，

máo tóu dàn qí bù máng
旄頭澹其不芒。

nán fēng xūn ér mín cái fù
南風薰而民財阜，

gāo yǔ shí ér nián gǔ chāng
膏雨時而年穀昌。

yú yǐ zhí dì wáng tài píng zhī yè
于以植帝王太平之業，

jù zhǐ tú bà gōng zhī fù qiáng
詎止圖霸功之富強？”

yú nǎi huò rán wù
余乃豁然悟，

jué rán qǐ
蹶然起，

bài shǒu ér jì zhī yuē
拜 手 而 系 之 曰 ：

tiān bú ài dào
“ 天 不 愛 道 ，

shèng xián xīng xī
聖 賢 興 兮 ；

dì bú ài bǎo
地 不 愛 寶 ，

jià sè dēng xī
稼 穡 登 兮 。

rén bú ài qíng
人 不 愛 情 ，

fù shòu qiě ān xī
富 壽 且 安 兮 ，

huà gōng zhī qiǎo
化 工 之 巧 ，

mò qióng qí duān xī
莫 窮 其 端 兮 。 “

[My] words are not yet finished,

there is a guest laughing [out loud] beside me and [still] smiling he says:

“You come from Po[yang],

that you know about the source [of fortune][720] is clear.

However, it is hard for the frog in the puddle[721] to talk about the ocean’s water

and the wine insect[722] did not yet have a peek at the light of the sky.

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[720] *Quan* 泉 originally means “fountain” or “source”, but also in particular “coins” as the “source of fortune”.

[721] *Kanwa* 坎蛙, the image of the frog in the puddle can be found in ZZJS chapter 6 (*qiushui* 秋水).

[722] *Xiji* 醯雞 is a so called “wine insect”. See LIZ chapter 1 (*tianrui* 天瑞).

Can it be that you alone have not heard about the one sitting with his back to a folding screen[723] and looking southward,

about the one turning the Great Wheel[724] and blowing the bellows towards the four directions?

He agitates the [system of the] Eight Trigrams

and takes as his measure the law of the nine categories.[725]

[He] lauds the 'Guanju'[726] and he propagates the song 'Wo jiang',[727]

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[723] *Fu yi* 負扆 means "to lean one's back on a folding screen". It stands for the emperor holding court audiences and dealing with government affairs. See *XZ* chapter 18 (*zhenglun* 正論).

[724] *Yangya* 坱圠 means "great" or "enormous". See HYDCD, vol. 2, p. 1076. *Jun* 鈞, i.e. *Dajun* 大鈞 means "the Great Wheel", which stands for the potter's wheel as a metaphor for the big nature. See WX *Funiao fu* 鵩鸟赋, "Like the rising of clouds, the falling of rain, things are complexly conjoined, intricately entwined. The Great Wheel shapes all things, boundlessly without limit. 雲蒸雨降兮，糾錯相紛。大鈞播物兮，坱圠無垠", WX / Knechtges, p. 45.

[725] Jiuzhang 九章 is the same with Jiuchou 九疇, refers to the nine categories of methods to govern the world, given by the Heaven to Yu the Great. See SHS chapter *Hong Fan* 洪範, "To him Heaven gave 'the great Plan with its nine Divisions', and thereby the proper virtues of the various relations were brought forth in their order. Of those divisions, the first is called 'The five Elements'; the second is called 'The Reverent Practice of the five Businesses'; the third is called 'Earnest Devotion to the eight objects of Government'; the fourth is called 'The Harmonious Use of the five Arrangements'; the fifth is called 'The Establishment and Use of Royal Perfection'; the sixth is called 'The Cultivation and Use of the three Virtues'; the seventh is called 'The Intelligent Use of the Examination of Doubts'; the eighth is called 'The Thoughtful Use of the various Verifications'; the ninth is called 'The Hortatory Use of the five Happinesses, and the Awing Use of the six Extremities' / 天乃錫禹洪範九疇，彝倫攸敘。初一曰五行，次二曰敬用五事，次三曰農用八政，次四曰協用五紀，次五曰建用皇極，次六曰乂用三德，次七曰明用稽疑，次八曰念用庶徵，次九曰嚮用五福、威用六極." SHS / Legge vol. 3, part II, p. 323f."

[726] Guanju 關雎, the first poem in the Shi Jing, so here it stands for classical poems in general. See HYDCD, vol. 12, p. 153.

he fuses all ranks of officials[728] with the help of the Bellows[729] of the Way and the Virtue[730]

and he gathers all the [scholarly] jewels with the help of the Examination of Moral and Talent.[731]

Those who are grinded but not chafed up[732]

he arranges in the Department of State Affairs,[733]

and those who [can] inspire [others] and make them perfectly harmonious,[734]

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[727] Wo jiang 我將 is a poem from Shi Jing, chap. Zhou Song 周頌. It goes "I have brought my offerings, a ram and a bull. May Heaven accept them! / 我將我享，維羊維牛，維天其右之". *Shi Jing*/Legge (1960), vol. 4, p. 575. The poem's theme is to ask for the blessing of Heaven as well as the ancestors in order to unify and pacify the whole country.

[728] *Shupin* 庶品 means all officials together, see HYDCD, vol. 3, p. 1234.

[729] *Tuoyue* 橐籥 means bellow. See LZ chapter 5.

[730] *Daode zhi tuo* 道德之橐 is from the sentence "It is indeed the potter's big wheel for humaneness and righteousness, it is indeed the smelter's bellow for moral and virtue. / 实仁义之陶钧，诚道德之橐籥也", see SUS chapter 32 (*jingji zhi yi* 經籍志一).

[731] *Junyi zhi chang* 俊乂之場, see XZZTJ chapter 9 (*Song ji jiu* 宋紀九) "[Emperor Taizong] wanted to obtain *junyi* in the imperial examination hall / [太宗] 欲博求俊乂於科場中", translation by the author. Junyi俊乂 means people who have outstanding moral and talent. Chang 場 refers to kechang 科場, i.e. the imperial examination hall.

[732] *Mo er bu lin* 磨而不磷 is from a sentence in LY, chapter 17 (*yanghuo* 陽貨), "But is it not said, that, if a thing be really hard, it may be ground without being made thin? Is it not said, that, if a thing be really white, it may be steeped in a dark fluid without being made black? / 不曰堅乎？磨而不磷。不曰白乎？涅而不緇". LY / Legge, vol. 1, p. 321. It is a metaphor for somebody who can keep his mind away from disturbances of the outside and stand the challenge.

[733] *Taisheng* 臺省 is a common unofficial reference to the Department of State Affairs (*shangshu sheng* 尚書省). See Hucker (1985), p. 481, item 6211.

[734] *Dong zhi si he* 動之斯和 is from a sentence in LY chapter 19 (*zizhang* 子張), "Were our Master in the position of the ruler of a State or the chief of a Family, we should find verified the description *which has been given of a sage's rule*: he would plant the people,

he establishes in the imperial court.
He turns around the heaven and rotates the earth, [735]
he closes Yin and opens Yang.
His [making of pottery] resembles the one of Yao, his smelting [of metal] the one of Shun,[736]
his [adjustment of] the compass resembles the one of the Zhou dynasty, his [measuring with] the angle gauge the one of the Shang dynasty.[737]
With rites and music he forms the customs
by which badness is turned into good.
With benevolence and righteousness he casts the people
by which viciousness changes into virtue.
The Great Ladder[738] brings peace,
and the Heavenly Steps[739] bring prosperity.

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and forthwith they would be established; he would lead them on, and forthwith they would follow him; he would make them happy, and forthwith multitudes would resort to his dominions; he would stimulate them, and forthwith they would be harmonious. While he lived, he would be glorious. When he died, he would be bitterly lamented. / 夫子之得邦家者，所謂立之斯立，道之斯行，綏之斯來，動之斯和，其生也榮，其死也哀。" LY / Legge, vol. 1, p. 349.

735 *Xuan qian zhuan kun* 旋乾轉坤 means to change the world, reverse the tide fundamentally. See HYDCD, vol. 6, p. 1608.

736 *Taoye* 陶冶 means making pottery and smelting metal, which together stands metonymical for civilizing and cultivating. Tangyu 唐虞 stands for Emperor Yao 堯 and Emperor Shun 舜 and indicates their reigns, times of peace and prosperity.

737 *Gui* 規 is a compass, *ju* 矩 is an angle gauge. *Guiju* is a means the standardiziation of moral and law.

738 *Taijie* 泰階, lit. "Great Ladder" lit. is an ancient name for a constellation of stars which looks like a ladder. When it looks even, it symbolizes a peaceful reign. See HS chapter 65 (*dongfang shuo zhuan* 東方朔傳).

739 *Tianbu* 天步, lit. "Heavenly Steps" means at the one hand the movement of the stars in general; at the other hand it means fortune and fate of a nation. See SJG chapter *xiaoya* 小雅, poem *Baihua* 白華.

The glaring light of the double halo [extends] for- and backwards,[740]
and the dim light of the Maotou[741] does not shine [too bright].
The southern wind[742] blows warmly, so that the peoples' wealth will be abundant,
and the moistening rain falls in time, so that the grain harvest will be prosperous;
thereupon he establishes the enterprise of imperial peace.
How could his plan just consist in wealth and power representing only the merits of a hegemon?"
Thus I suddenly became aware,
swiftly stood up,
bowed [to him], took up the conversation and said:

"If Heaven does not grudge its methods,
saints and sages appear.
if the Earth does not grudge its treasures,
cultivation and harvest [are] abundant.
If men do not grudge [the regulation of] their feelings,
there will be wealth, long life and peace.[743]

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740 *Qianxing* 前星, lit. "Front Star", is the name of a constellation of stars but also means "crown prince". See HS chapter 27 (*wuxing zhi xia zhi xia* 五行志下之下), "The heart, the big star is the heavenly king. Its front star is the crown prince. Its back stars are his [other] sons. / 心，大星，天王也。其前星，太子；後星，庶子也."

741 Maotou 旄頭 is the star, which is also called Huxing 胡星. It stands for the northern barbarian tribes. People believed that when it shined especially brightly, there would be war. See SJ chapter 27 (*tianguan shu* 天官書).

742 Nanfeng 南風 is an ancient song, said to be made by Shun. See KZJY chapter 8 (*bian yue jie* 辨樂解). For details concerning this song see Wang Shengduo (1999), p. 26.

743 These verses refer to a passage in the LJ chapter 9 (*li yun* 禮運), "The sage kings showed their sense of this state of harmony in the following way:-They did not make the occupants of the hills [remove and] live by the streams, nor the occupants of the islands [remove and live] in the plains; and thus the [people] complained of no hardship. They used water, fire, metal, wood, and the different articles of food and

As to the ingeniousness of the operations of nature in producing changes, nobody will ever find out the root of the matter."

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drink, each in its proper season. They promoted the marriages of men and women, and distributed rank and office, according to the years and virtues of the parties. They employed the people with due regard to their duties and wishes. Thus it was that there were no plagues of flood, drought, or insects, and the people did not suffer from bad grass or famine, from untimely deaths or irregular births. On account of all this, heaven did not grudge its methods; earth did not grudge its treasures; men did not grudge [the regulation of] their feelings. Heaven sent down its fattening dews; earth sent forth its springs of sweet wine; hills produced implements and chariots; the Ho sent forth the horse with the map [on his back]. Phoenixes and Khî-lins were among the trees of the suburbs, tortoises and dragons in the ponds of the palaces, while the other birds and beasts could be seen at a glance in their nests and breeding places. All this resulted from no other cause but that the ancient kings were able to fashion their ceremonial usages so as to convey the underlying ideas of rights, and embody their truthfulness so as to secure the universal and mutual harmony. This was the realisation of it. / 故聖王所以順，山者不使居川，不使渚者居中原，而弗敝也。用水、火、金、木，飲食必時，合男女、頒爵位必當年德，用民必順，故無水旱昆蟲之災，民無凶饑妖孽之疾。故天不愛其道，地不愛其寶，人不愛其情。天降膏露，地出醴泉，山出器車，河出馬圖，鳳皇麒麟，皆在郊棷。龜龍在宮沼，其餘鳥獸之卵胎，皆可俯而窺也。則是無故，先王能修禮以達義，體信以達順，故此順之實也". LJ / Legge, p. 392f.

3) Literary German Translation

The main objective of the following German translation of the *Daye fu* is not a maximum of accuracy in the understanding of the content, but rather to capture the literary style of the poem. It was attempted to provide a text, in which parallel linguistic structures are preserved, the language follows certain metric patterns and the lengths of verses in relation to each other are imitating the original text as closely as possible. Of course it is the nature of a translation especially from Chinese into a western language, that more syllables are necessary to express the same meaning.

The translation does not contain any annotations.[744]

Als ich nach Dongchu reiste meine Stelle anzutreten
da lebte ich der Münzstätte recht nah
und in der mir verblieb'nen freien Zeit
schrieb ich was ich gehört hatt' und gesehn in einem Büchlein nieder.
Bevor ich ging
dichtete ich alles dies zu einer Rhapsodie
sie klang wie folgt:

Als einst der Himmel und die Erde ihren Platz gefunden hatten,
da türmten sie die hohen Berge und erschmolzen breite Flüsse.
Wenn man der Erde vier zusammen mit des Himmels neun sich nimmt,
dann steht der Himmel für „Metall" und ist ein Teil des Zeichens „See".

744 This translation was published in the context of a larger article in the German mining history journal "Der Anschnitt", see Jost (2014).

Bringt man der Götter Tai und Ao verborg'ne Schätze an das Licht,
dreht man der Numinosität geheimnisvollen Angelpunkt.
Es waren Zhu, Ye, Fu, Li, Jia und Tao
die Sechse denen es gelang.
Von dem was ihrer Kunst entsprang,
war doch das wichtigste das Geld.

Suiren und Fuxi brachten es zuerst hervor,
der Gelbe Kaiser folgte und der Große Yu.
Familie Si und auch Tian Yi, sie gossen Münzen bei den Bergen Zhuang und Li,
und überstanden so die Katastrophen der neun schlimmen Jahre;
die Jis und Jiangs verteilten die Verantwortung auf neun Institutionen,
sie brachten Währungen wie Seiden- und auch Messermünzen in den Umlauf.
Familie Liu vergeudete die Vorschläge der sieben Reichtümer dann ungenutzt.
Das Monopol auf Salz und Eisen wurde überwacht vom Ministerium der Finanzen.
Verglichen mit den „Roträndern" und auch den „Ulmennüssen"
war'n die Wuzhu-Münzen alleine doch nur angemessen.
Sie passten zu der Weissagung vom weißen Wasser und zum Volkslied von dem gelben Büffel
und sie bestätigten die Weltenherrschaft der sechs Drachen.
Als Jinyang sich alsdann zu großer Höhe aufschwang,
belehnt' man Qi und Qin gleichwohl mit Münzgussrechten.

Die Münzen trugen Aufschriften in drei verschied'nen Stilen
dazu des Sichelmondes Abdruck wie er neu geboren.
Obgleich sie seit der Huichang-Zeit sich unterschieden durch der Präfekturen Namen,
blieb doch die alte Kaiyuan-Form bestehen.
Was nun die leichten Münzen angeht,

so nannte man sie „Seekannenblätter“, „Pflugscharen“, „Gänseaugen“ und „Fadenringe“.
Sie flogen im Wind und schwammen im Wasser.
Die schweren aber hießen
„Rädergleich“, „Zwei Zhu“, „Große Spaten“ und „Große Brunnen“
und sie gab es in Nennwerten von hundert bis zu tausend.
Ist Selbstsucht skrupellos zu frönen, Aufruhr und Chaos zu erzeugen
genug denn wirklich, um das rechte Maß zu nehmen für das allgemeine Wohl?

Am blauen Himmel ließ der Jupiter sich sehen
und der Vollkommene erstand in Zhuo
Die Fünf Planeten formten eine große Konjunktion
und zwei Gestirne rieben sich wohl aneinander.
Mit Sturmeswinden zogen Wolken auf am Himmel
Der Große Wagen tauschte seinen Platz mit dem Polarstern.
Die Kunlun-Berge legten flach sich nieder,
des Ozeanes Wogen wurden still.
Und Dongtingsee und Xiang-Fluss zähmten ihre Wellen
sogar der Pass von Jiange, er verlor seine Gefahr.
Im Fluge setzte dann des Kaisers Heer bei Caizhi über.
Erobert war die Kaiseraura von sechs Dynastien,
vereint waren zudem die Ländereien von Jiangnan.

Was Münzämter betrifft, so gibt es eines in Yongping,
das wie zuvor das Land von Chu auch kontrolliert.
Das Werk des Vorgängers wohl setzt ein jeder Kaiser fort,
mit gleicher Schrift und auch mit einheitlicher Wagenspur.
Des Himmels Siegel und das in der Form des Tigers
Mit Schrift im Vogel-Stil und feinsinniger Schönheit.
Die Bergbeamten kontrollieren streng die Monopole
und die neun Gouverneure richten Kisten mit Tributen.

Es gibt zudem die folgenden zwölf Münzgusspräfekturen:
„Ewige Fruchtbarkeit“, „Ewiger Durchbruch“, „Üppiger Reichtum“, „Reichtum des Volkes“, „Strahlender Friede“, „Großer Friede“, „Götterbrunnen“, „Schatzbrunnen“, „Fruchtbares Land“, „Fruchtbare Weite“, „Bereicherung des Volkes“ und „Nutzen des Volkes“.
Sie alle sind klar abgegrenzt und dabei doch auch eng verzahnt.
An dieser Stelle können sie nicht durch und durch behandelt werden.

Des Landes Ausdehnung reicht heute
vom Pan-Baum ganz im Osten
bis Danxue ganz im Süden,
von Taimeng ganz im Westen
bis Zhuli ganz im Norden.
Die Erde bringt hervor der Güter Menge.
Die Straßen führ'n zusammen die Tribute.
Gesammelt werden viele tausend Schätze
Kein Ort kommt dem Südosten jemals gleich.
Der Grund für dieses liegt wohl in der Großmut und der Güte seines Geistes
und deckt sich passend mit der fein geordneten Verteilung seines Landes.
Die Sterne Dou und Niu bedecken ihn und schmücken ihn mit Funkelstrahlen
Der Jangtse und der Han bewässern ihn und spenden ihm ihr göttlich' Wasser.
Dort zwischen Huai-Fluss und der See und zwischen Jingzhou und dem Heng-Berg,
dort sind Tribute die drei Güter
und in der Gegend zwischen Kuaiji-Berg und Tai-See
dort liegt der Nutzen in der Bronze.

Zur Hanzeit waren die Beamten für das Eisen einundfünfzig.
und diese waren ebenfalls zuständig für den Umgang auch mit Kupfer.
Zur Tang-Zeit waren die Schmelzöfen der Provinzen neunundneunzig.

und wichtig war's, das Eisen aus dem Land des Huai und auch des Jangtse zu betreuen.
Auf diese Weise wurden während dieser beiden Dynastien des Himmels und der Erde Schätze wohl verwaltet
und so war'n auch des Shaofus und des Shuihengs Lagerhäuser voll.
Und als dann die Moral des Feuers hell des Wohlstands Flammen antrieb,
und als die überschäumende Befruchtung durch der Harmonien Aura tief das Reich durchtränkte,
da fand ein wild daher gerannter Büffel, der die Flucht im Sinne hatte, Kupfer,
es fand ein schnell dahin geeiltes Reh mit einem überird'schen Geiste Silber.
Wenn Zinn und Gold und Silber bunt gemischt erscheinen
und man Zinnobermedizin zu diesem beigibt,
dann kann man auch nicht eines dieser Phänomene je erklären.

Der Staat begann von der Xingguo-Zeit an, Metalltransport zu Wasser und zu Land zu kontrollieren,
und man fing an von der Xianping-Zeit an Beamte für den Bergbau und den Münzguss zu ernennen.
„Vereinigt unter einem Münzamt seien Jiang, Huai, Jing, Zhe, Min und Guang".
besagten die Erlasse und Gesetze der Jingyou-Zeit.
„Des Ostens Leitung sei in Raozhou und des Westens Leitung sei in Qianzhou"
besagten die Dekrete und Befehle der Yuanfeng-Zeit.
Nur nach den umfangreichen Untersuchungen in der Chunxi-Zeit
vereint' man abermals die Leitung in Yongping.

Die gelben Banner und die violetten Dächer –
Des Himmels Schicksal hat sein Ziel gefunden,
Die süßen Quellen, Wagen und Geräte –
der Erde Göttlichkeit enthüllt ihre Geschenke.
Der Berg- und Hüttenwerke großer Reichtum
schlägt ruhmreich sich in den Verwaltungsämtern nieder

man kann sie Stück für Stück aufzählen:

„Bleiberg“, „Nebelberg“, „Steinwehr“, „Hügelwasser“, „Strahlender Schatz“, „Reicher Schatz“, „Schatzerfolg“, „Schatzglück“, „Doppeltes Glück“, „Gesegnetes Glück“, „Große Trefflichkeit“, „Großer Wohlstand“, „Ewige Blüte“, „Neue Blüte“, „Blühendes Land“, „Blühender Profit“, „Großer Reichtum“, „Weiter Reichtum“, „Durchbrechender Profit“ und „Durchbrechender Wohlstand“.

Die Schächte und die Stollen die zu überprüfen sind,
sie mögen wohl bis nahe an die zehntausende zählen.
Die einen sind ganz kläglich arm, während die andren reich sind,
die einen sind in vollem Blühn und and're sind verlassen.
Diejenigen die hier im Lobgesang behandelt werden,
sind doch nichts mehr als ein paar ausgewählte Exemplare.
Es geht so mancher Eisenberg einmal mit Kupfer schwanger
und viele Kupferstollen tragen Gold in ihrem Schoße.
Zu Zeiten trifft man Kupfer dann vermischt auch an mit Silber
und manchmal tunkt man es auch oder man laugt es heraus.
Ja selbst wenn Duanmu Ci, Fan Li, Kong Jin und Sanghong Yang den Nutzen diskutieren,
So kann von ihnen keiner dieses alles bis zur größten Tiefe je erklären.

Um Gold daraus zu waschen gibt es manche Sandbank,
und um Gold auszusieben, gibt es viele Haufen,
Ruijin hat eine Bergbaupräfektur
und Tongjin hat ein Monopolbüro.
Das Qi des Schatzes tritt voll Glanz zu Tage und sieht aus, als spiegle sich ein Regenbogen drin.
Sein glückverheißender Charakter übertrifft selbst den der Qilin-Füße und der Pferdehufe noch.
Das gelbe Gold aus Fengcheng,
es funkelt dort so glitzernd,

so wie die Chrysantheme, die im Herbst der Raureif ganz bedeckt;
schon stehen ihre Eiskristalle kurz davor hinabzufallen.
Das violette Gold aus Luoting ,
es leuchtet dort so strahlend,
so wie der Rohrkolben im Frühjahr sich wohl aus dem Wasser streckt;
noch wachsen seine flaumumhüllten kleinen Knospen nur sehr kurz.
Das feine, reine Gold aus Le'an,
ein glückverheißend' Embryo in Gruben und in Schluchten.
Die seichten Stellen zwischen mäandrierenden Flussufern werden ausgeschachtet, um zu sammeln.
Der Sand an Land wird aufgeteilt und abgetragen.
So groß wie frisch vom Busch gefall'ne Bohnen,
so klein wie Hirsekörner ohne Schale,
so leicht wie selbst das kleinste Stückchen Spelze,
so winzig wie die Flöckchen im Ferment.
sie setzen sich nach unten ab und werden ausgewaschen,
geschwinde und mit einem Sieb aus Schilf in beiden Händen.
Das helle Gold von Quyang,
das kostbar liegt im Bach und in der Höhle wie im Leibe seiner Mutter.
Man sucht nach Adern in bizarren Grotten, die zuweilen voll mit Wasser,
auf ihre Enden schlägt man mitten in mit Erde aufgefüllten Wänden.
Mit Feuer wird es dann erhitzt
so dass das Fett aus ihm hinausfließt wie durch große Hitze aus dem Eisenkäfig.
Mit Wasser wird es abgeschreckt,
so dass es mürbe selbst sich bricht wie durch die Schwere eines Stößels ganz aus Blei.
Dann glückverheißend zeigen sich die Barren endlich.
und ihren hellen Glanz sieht leuchtend man erstrahlen.
So gießt man sie zu einem heil'gen Dreifuß und macht einen guten Messbehälter.
Denn diese bringen wohl zehntausend Menschenaltern unerschöpflich großen Nutzen.

Es gibt die Hütte „Silberstadt“,
es gibt die Mine „Silberhalde“,
es gibt die Grube „Silberjade“,
es gibt das Bergwerk „Silberfels“.
Die Grube Baoji stellt sich dar als leere Höhle mit zehntausend Löchern.
Das Bergwerk Tianshou liegt auf einem hohen Berg, der aussieht wie ein Pfeiler.
Wer über seiner steilen Felsenwand steht, der schaut niemals ganz nach unten,
strebt eifrig nach Profit und vergisst so an seine Sicherheit zu denken.

Hinab durch steile, tiefe Schächte
und geradeaus durch eb’ne Stollen:
das Feuer in der Bambuslampe strahlt nach oben,
der Balken der im Wasser steckt, er drückt nach unten.
Mit Eimern legt man erst den Bauch des tiefen Schachtes trocken,
durch Feuersetzen bricht man dann die Rippen des massiven Felsen.
Das erste gleicht dem Frosch im flotten Sprung doch ist der nicht durch Seile festgebunden,
Das zweite einem grauen, grad geschnitt’nen Barte doch kann der nicht so leicht aufgelesen werden.

So wie des Donners Grollen klingt das Schlagen in den Fels und auch das Aufsammeln des Erzes,
und wie des Regens Plätschern klingt das Waschen in dem Becken und das Rühren in der Paste.
Es spiegelt heller Glanz das Licht
und Sterne über Sterne funkeln.
Ist erst der Silber-Reis-Ball gar,
dann bricht der „An“-förmige Ofen.
Und wenn der Bleiklumpen erst kocht,
dann öffnet sich das Aschenest.
Das Qi entweicht in einer Wolke Rauch,

die Blumen werden nach und nach zu Schnee.
Kein andrer Berg ist ihm je überlegen,
selbst Shuti ist mit ihm verglichen schlechter.
Das Kaiserliche Schatzhaus nutzt es um damit Beamte zu beschenken.
Zudem nimmt man es um damit das finanzielle Defizit der Bergämter zu decken.
Und so verhält es sich dann also mit dem zweiten Gut.

Nun lasst uns denn in gleicher Form auch Kupfer untersuchen und erklären.
Die Produktion des Staates Wu gedieh in Yuzhang,
wo einst Liu Bi in einem Bergnest flüchtige Verbrecher um sich scharte
und sich des Bergbaureichtumes bemächtigt' ohne Legitimation.
Die Produktion des Staates Shu war reich in Linqiong,
wo die Familie Zhuo einst Anspruch auf des Herrschers Vorteile erhob
und des gemeinen Volks Gewerbe für sich selber monopolisierte.
Schmelzmeister Ou schnitt in den Chijin-Berg
und trocken legte er den Ruoye-Bach.
so dass die Produktion des Staates Yue nicht auf die Schwerter Moye und Ganjiang beschränkt blieb.
Manch eine Münze machte man in den Regionen Chu und Jin,
und Guss und Schmelzen blühten in den Dynastien Qi und Liang.
Seit Fuxis Zeit gibt es 467 Kupferberge.
Trotzdem kennt man im Grunde heute doch von Kupfer nicht mehr als drei Typen.

Davon ist eines „Gelbes Kupfer".
wofür es Gruben gibt mit sehr zahlreichen Namen.
Die Berge haben Vorkommen in vielfältigen Arten,
sie tauchen auf in steigenden, gewundenen Spiralen,
sie häufen sich zusammen zu massiven, großen Blöcken.
Auf schroffem, unwirtlichem Boden hoher steiler Berge,
dort zeigen sich die Ausbisse mit farbenfrohem Schillern

und zudem auch mit Glänzen und voll großer Helligkeit.
Verborgene Erzadern kommen an die Oberfläche
und auch verdeckte Flöze strahlen ihren Schimmer aus.
Die „Kuh beim Trinken“ steigt hervor,
Der „Himmelsbrunnen“ führt hinab.
Des Erzes Muster hat verschied’ne Farben;
hier ist es rein, dort plötzlich bunt gemischt.
Die Adern sind von ganz verschied’ner Art;
hier brechen sie, dort setzen sie sich fort.
bestückt mit dunklen Flecken wie aus Klebstoff,
durchwirkt mit goldnen Sternen die dort funkeln,
mit leichter Farbe so wie eine gelbe Blume,
mit dunkler Farbe so wie tiefroter Zinnober,
ganz so wie Mäuse, die zu einem Rudel sich versammeln
ganz so wie Hühner, die verängstigt auseinanderstieben,
wie fettige und ölige Reiskuchen,
so leuchtend und so glänzend und so blank.

Durch starkes Feuer über Nacht versprödet, spaltet sich der Stein,
mit zahlreichem Gezähe dann zerschlägt man kundig ihn in Stücke.
Und man haut an das steile Kliff, wie einst der Hammer bei Bolang,
man dringt in den massiven Fels, wie einst der Meißel in Hundun.
Der Staub im Berg will sich erheben, doch er legt sich wieder,
Die Steinfunken bläst niemand an, doch springen sie von selber.
„Pang, pang“, so grollt es wie der Donner,
„Pæwk, pæwk“, so prasselt es wie Hagel.
Die Hügelgeister halten sich die Ohren zu und fliehen eilends,
die Waldgespenster greifen an die Herzen sich voll Angst und Schrecken.
Der Mut der Kui und Wang, die in der Wildnis kriechen, ist gefroren,
die Seele hauchen Drachen und Gewürm im Schlamme suhlend aus.
Wie sind die langen Stollen so gewunden

und wie so finster sind die tiefen Schächte!
Verdeckte Höhlen öffnen sich an ihren Seiten
und dunkle Tunnel formen schräge Löcher.
Gong Gong zerschmetterte den Buzhou-Berg, wodurch die erdtragenden Seile Schaden nahmen,
der große Yu brach durch Yique, wodurch das Drachentor geöffnet wurde,
am Li-Berg grub man bis auf eine Tiefe von acht ren,
am Kunming-See arbeiteten Zehntausende zusammen,
doch nichts von alledem kann den Vergleich mit der gewalt'gen Kraft des Bergbaus je bestehn.

Sind erst die Tragekörbe vorbereitet
und auch die Schaufeln stehn parat,
dann trägt Zhuan Zhu wild wie ein Tiger,
dann schleppt Meng Ben stark wie ein Eber
Sie schütten Hügel auf im flachen Land
und bauen Türme auf am Ofenplatz
Sie legen glänz'ge Holzkohle darum herum
und fügen trocknes Feuerholz dann rings hinzu.
Wie eine Stadt zum Niederbrennen,
wie eine Mauer zum Entzünden.
Erst binden sie ein Leinentuch mit einem Feuervogel,
dann blasen sie den Blasebalg mit hellem Flammenlodern.
Sie peitschen auf den Feuerbüffel, dass er brüsk davonstürmt
und reiten auf dem Feuerdrachen, dass er schnell emporsteigt.
So lässt man Blitz und Donner sich im wilden Flammenmeer bekriegen
und lässt Pingyi und Fenglong in den Rauchwolken die Waffen schwingen.
Der Sonnenvogel ist schon seines Scheins beraubt
und Mars dankt gleichfalls ab von seiner Position.
Der Stein lässt dann sein Mark aufbrechen.
Der Kern lässt seine Milch ausfließen.

Wie einst auch schmolz die Jangtse-Sperre
und wie das Fett floss aus dem Nabel.
Wenn man das Erz noch einmal schmilzt, verringert sich die Rohheit.
Wenn man das Rohkupfer erhitzt, erhöht sich seine Reinheit.
Bläst man den Balg und feuert an, so fließt die Kupferschmelze aus,
pustet und fächert man dann noch, so kommt das Silber auch hervor.

Groß ist ganz sicher der Profit,
doch äußerst hart ist auch die Arbeit.
Nur von manch einer Quelle, manchem Brunnen,
kann man den ausgewasch'nen Sand gleich gießen.

Was nun das Tunkekupfer aber anbetrifft,
so war'n Yanshan und Xingli hier zuerst erfolgreich.
Ihr Beispiel breitete sich überallhin aus.
Dort lernte man es und machte es sich zu eigen.
Man urteilt über sie mit einem Munde wie dem des Yi Ya,
denn Vitriole sind von ganz verschiedenem Geschmack:
Blau-grün und herb bis bitter, dieses ist das allerbeste,
und Gelb und saftig-sauer, dieses folgt an nächster Stelle.
Man richtet über sie mit Augen wie denjen'gen des Li Lou,
denn auch der Schaum auf ihnen sieht ganz unterschiedlich aus:
Rot-weiß ganz durcheinander, dieses schätzt man als höchst wertvoll,
und Lila vor Zinnober, dieses ist auch gut zu nutzen.

Die Teiche und die Becken sind voll Wasser,
das berstend überläuft in die Kanäle.
Mit Sprudeln und mit Gurgeln, breit und tief,
im schnellen Fluss, die Wellen überschlagend.
So wie das Traufenwasser an der Kupfersperlingsplattform,
wenn es durch Rinnen aus zehntausend Ziegeln rauscht: dzowng, dzowng,

So wie der Wasserstrom im Drachenknochengraben,
wenn er in tausend Bächen auf die Felder fließt: kwet, kwet.
Man misst die Tiefe und man zieht die Gräben.
Je nach Entfernung baut man Schleusentore.
Es schlucken und es spucken nacheinander diese;
es strecken sich und liegen wohlgeordnet jene.

Dann schlägt man Pfannen, in denen man nicht mehr brät, in Scherben
und man bricht Kessel, in denen man nicht mehr kocht, in Stücke.
Sie liegen dort wie Schuppen
und steh'n hervor wie Flossen.
Man wäscht sie: ljowng, ljowng
und spült sie: tsyhiX, tsyhiX,
durch Tunken und durch Tränken werden sie von außen bis nach innen ganz durchdrungen.
Mit Dämpfen und mit Gären geht dies Tag und Nacht so, immer weiter ohne Pause.
Yuanming bringt seine großartige Fähigkeit zum Einsatz,
Yanghou trägt seinen außerordentlichen Genius bei.
Der Rost verwandelt sich in Schaum,
das Herbe ändert sich zum Milden.
Siebt man es durch die Bambusmatte,
klumpt es von selbst zu Perln und Bällchen.
Man wäscht es und man lässt es ziehen,
dann ist der Wandel ganz vollzogen.
Man wirft es in den Ofen und man bläst,
dann wird es reines, schönes Kupfer.

Was nun das Auslaugkupfer aber angeht,
so nahm es seinen Anfang einst in Censhui,
von dort erreichte es dann erst Yongxing.

Das, was das Qi der Erde hat genähret,
kann wahrlich man als analog vergleichen:
Die Erde hält das Vitriol und lässt es im Verborgnen wachsen.
Für Dächer dreht man Seile und kann sie geschwinde dann erklimmen.
Man unterteilt im großen Stil
und greift die steilen Berge an.
Man trägt den Oberboden ab
und bringt den Untergrund hervor.
Wenn man dann erst des Huhnes gelben Eidotter erreicht,
erkennt man auch wo sich das Erz der Erde konzentriert.
Die Wagen zum Transport verstopfen bald die schmalen Wege.
Die aufgetürmten Halden übertreffen hohe Säulen.
Je mehr der Tag' vergehen, desto größer seine Stärke
Kommt Vitriol hervor, rollt es herab wie kleine Steinchen.

Dann werden Siebe und auch Bambusnetze vorbereitet und man lädt es auf sie.
Es werden Ziegelgräben und auch Bambuskörbe aufgebaut um zu filtrieren.
Streut man nun Eisenblättchen und verteilt man sie darin
und gießt man diese mit der Flüssigkeit des Erzes sinken sie.
Wenn kraftvoll man die Fässer hochhebt fließt das Wasser.
Wenn man die Kürbiskelle sachte dreht so platscht es.
Wie beim Geschmack der Flüsse Zi und Sheng kann stark und fad man trennen,
wie bei den Flüssen Jing und Wei kann trüb und klar man unterscheiden.
Der Klang des Sickerns und des Schüttens,
wie wenn man Wein aus einem Haufen fermentierten Reises in der Lagerküche quetscht.
Die Anlagen zum Wasserleiten,
wie wenn der Wasserhubbeamte mit dem „Durst'gen Raben" seine Wasseruhr befüllt.
Links schöpft man ab und gießt nach rechts,
ununterbrochen ohne Ende.

Es tröpfelt und es gießt bei Tag und Nacht
und diffundiert   bis alles sich vereinigt.
So bildet durch Magie heraus ein Stoff sich, den selbst Hitze, Kälte, Nässe oder Trockenheit nicht ändern können,
ganz so als wär' das Eisen in Kontakt mit einer mächtigen Essenz.

Danach kann man die Bergsteuern erheben.
Konvoitransporte drängt man schnell zum Aufbruch.
Es geht das Eisen und es kommt das Kupfer.
Das Zinn kommt an, das Blei das reicht man weiter.
Es schwimmen auf den Flüssen Bug und Heck in dichter Folge,
Es reisen über Land die Wagen und die Träger wie in einer Reihe.
Sie kommen von den Lingqiao-Bergen
hinab nach Jing und auch nach Shu.
Sie rasen wie Kometen über den Poyang- und auch den Dongting-See,
sie jagen wie der Blitz gegen den Strom den Jangtse und den Huai-hinauf
aus den vier Himmelsrichtungen dem kaiserlichen Schatzamt zu,
wie jede Speiche eines Rades hin zu seiner Nabe führt.
Welch ratternd' Getöse unzähliger Räder
in Ketten von hohem und steilem Gebirge!
Legt man die Barren aneinander, so kann Städte man damit verbinden.
und will man sie im Lager stapeln, füllt man damit ganze Häuserreihen.
In schwarzen Wolken auf zerfurchten Bergen biegt und windet sich der Weg verworren,
Bei Bär und Leopard in leeren Tälern führt der Pfad hinauf und auch hernieder.
Dafür muss keiner mehr ein Standbild weder des Feilian noch Sakyamunis je einschmelzen,
denn für den Münzdirektor steht genug stets zur Verfügung.

Zu dieser Zeit
prüft dann der Münzbeauftragte die Farbe der Legierung.
Der Kupfereinstufungsdirektor schätzt die Güte ein.
Die Arbeiter sind tätig bis zur gänzlichen Erschöpfung,
die Handwerker bemühen sich nach allen ihren Kräften.
Die Schornsteine sind sauber und in Ordnung
die Haushalte der Köhler sind sehr zahlreich.
Man bläst die Blasebälge der zwei Kräfte und dies führt zu heftiger Bewegung.
Man nutzt die Wirkmacht der sechs Götter für die Tätigkeit im Wechsel und im Umlauf
und Zhurong handelt
und Nüwa fördert.
Der erste Stoß: Die leichten Wellen an der Küste schaffen eine große Woge;
der nächste Stoß: Das vielschichtige Morgenrot am Fusang-Baum enthüllt die Sonne;
der dritte Stoß erwärmt der Dämm'rung Wolken und erhellt sie gänzlich;
der vierte Stoß erweckt des Donners Grollen, dass es anfängt zu erbeben.
Es zeigen sich des Sternes Heze glänzendhelle Strahlen,
und es ergießt sich des Kometen Chanqiang scheinend Schimmern.
Wenn Kuafu sich dem Feuer nähert
erstarrt sein Schweiß und er erleidet einen Hitzeschlag
Wenn Hebo in das Feuer schauet
so blendet es ihm die Pupillen dass er blinzeln muss.
Vollständig durchsichtig und ohne Schmutz,
durchgehend hell und ohne Aschestaub.
Hat sich der trübe schwarze Rauch verzogen folgt ihm gelber Rauch,
hat sich der weißlich-gelbe Rauch verzogen folgt blau-grüner Rauch.

Die Schmelze fließt alsdann auch ganz geschwinde in die Kelle,
die Sandformen mit Abdrücken der Muster steh'n bereit.
Man bricht die Münzen ab: lak, lak

und steckt sie auf den Stab: lin, lin
Sie werden mit dem quietschenden Geräusch des Windrades entgratet.
und werden mit dem knirschenden Geräusch des Wasserrads geschliffen.
Man wischt sie erst mit einem Seidennetz
und scheuert sie dann mit Geitreidespreu.
Ihr Ring und ihre Löcher bilden ein vollkommenes Profil,
solide, strahlend, vornehm und sehr scharf geschnitten seh'n sie aus.
So kräftig wie die Silberhakenschrift ist die Legende,
so glänzend als bestünden sie aus Jade ist die Farbe.
Erst wenn der letzte Schmutz entfernt und alles glattpoliert ist,
dann kann man sie auf Fäden ziehen und zur Waage bringen.
Wenn aller Flachs, den man am Osttor röttet, aufgebraucht ist,
so reicht dies dennoch nicht, um den Bedarf an Schnur zu decken.

Es melden ihre lobenswerten Taten die wohl hundert Angestellten.
Es zeigen auch in den drei Ämtern die Gesichterfarben viel Bewegung.
So überwachen sie die Schiffe zum Transport
und sie verteil'n die Münzen überall im Reich.
Das Steuerministerium, es überprüft die Zahlen der Gewinne und Verluste,
das Arbeitsministerium, es inspiziert den Grad der Feinheit oder Rohheit.
Hier sorgt man für das Wachstum in der Schatzkammer des Kaisers,
dort fördert man die Mehrung in der Schatzkasse des Staates.
Die eine führt der Himmelssohn mit Sparsamkeit und mit Respekt,
die andere verwahrt der Kanzler, pflichttreu und mit Lauterkeit.
Gemeinsam mit den Wuzhu- und den Kaiyuan-Münzen sind sie stets im Umlauf
nicht wie beim selbstsüchtigen Horten einst mit gelbem Schild und lila Zeichen.
Für Hüttenleute, die sie schmelzen wolln gibt es Verbote,
Für Südseeschiffe, die sie exportieren, gibt es Strafen.
Es scheint, dass in der Hauptstadt unbeachtet Münzstränge verrotten,
und die man unterm Himmel lagert, gleichen einem ganzen Berge.

Die Tatsache, dass man zuweilen Hirschleder benutzte,
und zudem „Flugkäsch" beigemischt hat,
der Dinge Wandel durchzustehen,
der Zeiten Schwanken abzustützen.
Sie gründet sich darauf, dass stets das Schwere und das Leichte doch einander helfen sollen
und dass die Mutter und ihr Kind im Gleichgewicht sich halten.
Geht man daran, des Reichtumes Vermehrung zu besprechen,
so kommt doch nichts der Wahl des richtigen Beamten gleich.
Denn als Guan Zhong im Amte war, da wurd' die Kasse reich im Staate,
Und als Liu Yan berufen wurde, schwamm das Geld selbst auf dem Boden.

Und meine Worte sind noch nicht am Ende,
da lacht ein Gast an meiner Seite schallend auf und sagt:
„Ihr kommt ja g'rade aus Poyang daher,
dass über Münzen Ihr Bescheid wisst, ist doch klar.
Wie schwer fällt es dem Frosch in seinem Tümpel doch, vom Meerwasser zu reden,
noch nie hat auch das Gärinsekt im Weine je des Himmels Licht erspähet!
Hast wirklich Du allein noch nie von dem, der mit dem Blick nach Süden vor der Faltwand sitzt gehört?
Dem, der die große Töpferscheibe dreht, und dem, der in vier Richtungen die Blasebälge bläst?
Er ist es, der die Ordnung der acht Trigramme bewegt,
der das Gesetz der neun Kategorien zum Maße nimmt.
Er singt zum Preis das Lied ‚Guan Ju'
und er verbreitet das ‚Wo Jiang'.
Er ‚schmilzt' Beamte aller Ränge mit dem Blasebalg des Weges und der Tugend
und er versammelt die Juwelen durch die Prüfung der Moral und der Begabung.
Die, die geschliffen aber nicht zermalmt sind,
die teilt er ein ins Ministerium des Staates.

Die, die selbst and're noch zur Harmonie bewegen,
die setzt er ein am kaiserlichen Hofe.
Er dreht den Himmel und er lässt die Welt rotieren
und er verschließt das Yin und er macht auf das Yang.
Sein Töpfern ist wie das des Yao, sein Schmelzen ist wie das des Shun.
Sein Zirkel ist wie der der Zhou, sein Winkel ist wie der der Shang.
Mit Riten und Musik formt er die Sitten,
hierdurch verkehrt Verderbtheit er zum Guten.
Mit Güte und Moral gießt er die Menschen,
hierdurch verwandelt Laster er in Tugend.
Die große Leiter bringt den Frieden,
des Himmels Schritte bringen Wohlstand.
Es scheint des Qianxing gleißend' Licht nach vorne und zurück,
doch strahlt des Maotou trübes Leuchten nicht mit solcher Kraft.
Der Südwind weht mit Wärme, darum fließt des Volkes Reichtum über,
der Regen fällt rechtzeitig, darum ist des Jahres Ernte reichlich.
Denn darauf baut er des imperialen Himmelsfriedens Unterfangen,
Wie könnte da sein Plan in Macht und Reichtum je, den Werten von Tyrannen, sich erschöpfen?"

Da wurde es mir plötzlich offenbar
und ich erhob mich zügig.
Ich neigte mich vor ihm, ergriff das Wort und sprach:
„Geizt nur der Himmel nicht mit seinem Dao,
so treten Heilige und Weise auf.
Und geizt die Erde auch mit ihren Schätzen nicht,
so werden Frucht und Ernte überreich.
Geizt auch der Mensch mit seinen Sinnen nicht,
so kommen Reichtum, langes Leben und auch Frieden.
Doch was den Genius dessen angeht, der des Wandels Werke tut,
so wird wohl niemand seinen allertiefsten Ursprung je versteh'n."

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BCGM *Bencao gangmu* 本草綱目 (Compendium of materia medica) by Li Shizhen 李时珍 (1518-1593).

BCJKZ *Bencaojing kaozhu* 本草經考注 (Study on the classical pharmacopeia), written in 1858 by Mori Tateyuki 森立之.

BZL *Baozang lun* 寶藏論 (Discussion on the precious patrology) by Xuanyuan Shu 軒轅述 (living in the Five Dynasties, i.e. 907-979), non-existent, quoted in BCGM.

BCJJZ *Bencao jing jizhu* 本草經集注 (Collected commentaries on the classicial pharmacopoeia of the Heavenly Husbandman) by Tao Hongjing 陶弘景 (452-536), non-existent, reconstituted by Shang Zhijun 尚志鈞 and Shang Yuansheng 尚元勝, Beijing: Renmin weisheng chubanshe, 1994.

BMTZ *Bamin tongzhi* 八閩通志 (Gazetteer of Fujian) by Huang Zhongzhao 黃仲昭, 1489.

CXSSZ *Chunxi sanshan zhi* 淳熙三山志 (Gazetteer of Fuzhou from the Chunxi Reign Period). 1189.

CXZHJSZLBYBC *Chongxiu Zhenghe jingshi zhenglei beiyong bencao* 重修政和經史證類備用本草 (Revised version of classified and consolidated pharmacopoeia of the Zhenghe Reign-period [1111-18]) by Tang Shenwei 唐慎微 (ca. 1056-1093), published in 1249.

DNKCTL *Diannan kuangchang tulüe* 滇南礦廠圖略 (Illustrated account of the mines and smelters in Yunnan). Wu Qijun 吳其濬 (comp.), illustrations by Xu Jinsheng 徐金生. (n.pl.), 1844.

DPQJ *Dongpo quanji* 東坡全集 (Complete collection of [Su] Dongpo), by Su Shi 蘇軾 (1037-1101).

DSFYJY *Dushi fangyu jiyao* 讀史方輿紀要 (Essentials of geography for reading history) by Gu Zuyu 顧祖禹, 1692.

DXHHJWL *Dao Xian huanhai jianwenlu* 道咸宦海見聞錄 (Officialdom travelogue during Dao[guang] and Xian[feng] reign-periods) by Zhang Jixin 張集馨 (1800-1879). Beijing: Zhonghua shuju, 1981.

EY *Erya* 爾雅, 3rd century BC.

GY *Guo yu* 國語 (Discourses of the states), probably compiled beginning in the 5th century BC and continuing to the late 4th century BC.

GZ *Guanzi* 管子, edited by Liu Xiang 劉向 in 26 BC.

HFZ *Hanfeizi* 韓非子, at the end of the Warring States period (475 BC- 221 BC).

HGZ *Heguanzi* 鶡冠子, written in the Warring States period (475 BC- 221 BC).

HHS *Hou Han sh*u 后漢書 (History of the Later Han) by Fan Ye 范曄 (398-445), compiled in the 5th century.

HNWBS *Huainan wanbi shu* 淮南萬畢術 (Ten thousand infallible arts of the Prince of Huainan) by Liu An 劉安 (c. 200 BC- 122 BC), non-existent, reconstituted by Sun Fengyi 孫馮翼, in: Congshu jicheng chubian 初編叢書集成 (Complete collection of books from [various] collectanea)

HNZ *Huainanzi* 淮南子 (Masters/Philosophers of Huainan) by Liu An 劉安, 2nd century BC.

HS *Han shu* 漢書 (Book of Han) by Ban Gu 班固, finished in AD 111.

HS / Dubs - Dubs, Homer H. (1955): *The history of the former Han dynasty. Translation*. Baltimore: Waverly Press.

JDZSZP /JTYLHX (ZT) *Jiadao Zhang shi zongpu* 甲道張氏宗譜 (Genealogy of Zhang family in Jiadao)/ Jintong yaolüe houxu 《浸銅要略》後序 (Colophon of "Important aspects of steeping copper") by Zhang Tao 張燾, written in 1154, preserved version from 1765, chap. 41. In: *Zhonghua zupu jicheng: Zhang shi pujuan* 中華宗譜集成：張氏譜卷 (Collections of Chinese genealogies: Zhang families), vol. 9-11. Chengdu: Bashu shushe, 1995.

JDZSZP/JTYLX(ZJ) *Jiadao Zhang shi zongpu* 甲道張氏宗譜 (Genealogy of Zhang family in Jiadao) / Jintong yaolüe xu 《浸銅要略》序 (Preface of "Important aspects of steeping copper") by Zhang Jia 張甲, written in 1094, preserved version from 1765, chap. 41. In: *Zhonghua zupu jicheng: Zhang shi pujuan* 中華宗譜集成：張氏譜卷 (Collections of Chinese genealogies: Zhang families), vol. 9-11. Chengdu: Bashu shushe, 1995.

JS *Jin shu* 晉書 (Book of Jin) by Fang Xuanling 房玄齡 et al., compiled in 648.

JTS *Jiu Tang shu* 舊唐書 (Old book of Tang) by Liu Xu 劉昫, 945.

JXTZ *Jiangxi tongzhi* 江西通志 (Gazetteer of Jiangxi Province) by Xie Min 謝旻, Compilation started in 1729.

KJZ *Kuaiji zhi* 會稽志 (Gazetteer of Kuaiji) by Shi Su 施宿, 1201.

KZJY *Kongzi jiayu* 孔子家語 (School sayings of Confucius), edited in the early Han dynasty.

KZJY / Legge - Legge, James; Ride, L. T. (1960): *The Chinese Classics. Confucian Analects, the Great Learning, the Doctrine of the Mean.* Hong Kong: Hong Kong University Press.

LCLZ *Longchuan luezhi* 龍川略志 (Brief jottings of Dragon-stream), written in 1099 by Su Zhe 蘇轍 (1039-1112), reprinted by Beijing: Zhonghua shuju, 1982.

LIZ *Liezi* 列子, compiled in the 4th century BC.

LJ *Li ji* 禮記 (Classic of rites), edited during the West Han (202 BC-9 AD).

LJ / Legge - Legge, James; Chai, Ch'u; Chai, Winberg (1967): *Li Chi. Book of Rites : an Encyclopedia of Ancient Ceremonial Usages, Religious Creeds, and Social Institutions*. New York: University Books.

LJT *Liu jing tu* 六經圖 (Illustrations of the six classics) by Yang Jia 楊甲 (ca. 1110-1184). *Siku quanshu* version 四庫全書本.

LWDD *Lingwai daida* 嶺外代答 (Notes from the land beyond the passes) by Zhou Qufei 周去非, written in 1178, annotated by Yang Wuquan 楊武泉, Beijing: Zhonghua shuju, 1999.

LY *Lun yu* 論語 (Analects of Confucius), written during the Spring and Autumn Period through the Warring States Period (ca. 475 BC-221 BC).

LZ *Laozi* 老子, around 6th century BC.

MXBT *Mengxi bitan* 夢溪筆談 (Brush talks from Dream Brook), by Shen Gua 沈括 (1031-1095) written between ca. 1086-1093, reprint by Beijing: Zhonghua shuju, 2009.

MZ *Mengzi* 孟子, written in the middle to late Warring States period (475 BC- 221 BC).

NS *Nan shi* 南史 (History of Southern Dynasties) by Li Dashi 李大師 and Li Yanshou 李延壽, between 643 and 659.

OYWZGWJ *Ouyang wenzhong gong wenji* 歐陽文忠公文集 (Collected works of Ouyang Xiu) by Ouyang Xiu 歐陽修 (1007-1072), *Sibu congkan* version 四部叢刊本.

PZWJ / DYF *Pingzhai wenji* 平齋文集/ *Daye fu* 大冶賦 by Hong Zikui 洪咨夔 (1176-1236), *Sibu congkan* version 四部叢刊本.

QBZZ *Qingbo zazhi* 清波杂志 (Memoirs of the green wave) by Zhou Hui 周煇 (1126-?), first print 1192, republished by Beijing: Zhonghua shuju, 1994.

QT *Qian tong* 錢通 (Generality of money) by Hu Wokun 胡我琨, lived during the late Ming period. *Siku quanshu* version 四庫全書本.

SFHT *San fu Huang tu* 三輔黄圖 (Yellow [i.e. imperial] maps of the three metropolitan areas). No later than the Southern and Northern dynasties (420-589). *Sanguo zhi* 三國志 (Records of Three Kingdoms) by Chen Shou 陳壽 (233-297), written in the 3rd century.

SHJ *Shanhai jing* 山海經 (Collection of classics of the mountains and seas), written from the early period of the Warring States (475 BC-221 BC) to the beginning of the Han Dynasty. (202 BC-9 AD).

SHJ / Birell - Birrell, Anne (1999): *The classic of mountains and seas*. London: Penguin.

SHS *Shang shu* 尚書 (Documents of the elder).

SHXZ / 1939 *Shanghang xianzhi* 上杭縣志 (Gazetteer of Shanghang District) in Fujian, version of 1939.

SHYJG / FY - *Song huiyao jigao/Fangyu* 宋會要輯稿/方域 (Song Dynasty manuscript compendium, territorial issues), written during the Song dynasty, extracted by Xu Song 徐松 (1781-1848) in part from the Ming Dynasty Yongle Encyclopedia published in 1408 CE.

SHYJG / L - *Song huiyao jigao/Li* 禮 (Rites).

SHYJG / SH - *Song huiyao jigao / Shihuo* 食貨 (Food and commerce).

SHYJG / XF - *Song huiyao jigao / Xingfa* 刑法 (Punishment).

SHYJG / XJ - *Song huiyao jigao / Xuanju* 選舉 (Selection of officials).

SHYJG / ZG - *Song huiyao jigao / Zhiguan* 職官 (State offices).

SJ *Shi ji* 史記 (Records of the grand historian) by Sima Qian 司馬遷, written from 109 BC to 91 BC.

SJ / Nienhauser - Nienhauser, William H.; Cheng, Tsai Fa; Cao, Weiguo (1994): *The Grand Scribe's Records*. Bloomington: Indiana University Press.

SJG *Shi jing* 詩經 (Book of songs), compiled probably in the early West Zhou (1100 BC- 771 BC)

SJG / Legge - Legge, James (1960): *The Chinese Classics. The She King*. Hongkong: Hongkong Univ. Press.

SJZY *Shi ji zhengyi* 史記正義 (The correct meanings of the *Shi ji*) by Zhang Shoujie 張守節, written during the Tang period (618-907).

SNBCJ *Shennong bencao jing* 神農本草經 (Classical pharmacopoeia of the Heavenly Husbandman), date and authorship unknown, edited to a book form before the 2nd century AD and based on earlier material, non-existent, reconstituted and annotated by many scholars, one being Gu Guanguang 顧觀光 (1799-1862), annotated by Yang Pengju 楊鵬舉. Beijing: Xueyuan chubanshe.

SUS *Sui shu* 隋書 (Book of Sui) by Wei Zheng 魏徵 et al., finished in 636.

SYZJ/LQXZ *Shuyuan zaji* / *Longquan xianzhi* 菽園雜記/龍泉縣志 (Collection of miscellaneous notes from bean garden/Gazetteer of Longquan district) by Lu Rong 陸容 (1436-1494). Beijing: Zhonghua shuju, 1985.

SS *Song shi* 宋史 (History of Song) by Tuotuo 脫脫 et al., 1345.

TGKW *Tiangong kaiwu* 天工開物 (Exploitation of the works of nature) by Song Yingxing 宋應星, finished in 1637.

TGKW / Herrmann – Herrmann, Konrad (tr.)(2004): *Erschließung der Himmlischen Schätze*. Bremerhaven: Verlag für Neue Wissenschaft.

TGKW / Sun - Sun, E-tu Zen & Sun, Shiou-chuan (1966): *T'ien-kung k'ai-wu: Chinese Techniques in the Seventeenth Century.* University Park: Pennsylvania State University.

THY *Tang huiyao* 唐會要 (Institutional history of Tang) by Wang Pu 王溥, 961.

TPHYL *Taiping huanyu ji* 太平寰宇記 (Universal geography of the Taiping [xingguo] reign-period [976-983]) by Yue Shi 樂史

TPYL *Taiping yulan* 太平御覽 (Imperial overview from the Taiping [xingguo] reign-period [976-983]) by Li Fang 李昉 et al.

TXJGLBS *Tianxia junguo libing shu* 天下郡國利病書 (On benefit and faults of the empire's local administration) by Gu Yanwu 顧炎武 (1613-1682).

TY *Tanyuan* 談苑 (Garden of discussions) by Kong Pingzhong 孔平仲 (?-1065-1103-?).

WASWJ *Wang Anshi wenji* 王安石文集 (Collected works of Wang Anshi) by Wang Anshi 王安石 (1021-1086).

WDHY *Wudai huiyao* 五代會要 (Institutional history of the Five Dynasties) by Wang Pu 王溥, 963.

WYCJ *Wu Yue chunqiu* 吳越春秋 (Spring and Autumn of Wu and Yue) by Zhao Ye 趙曄 (probably 25-56 AD), East Han dynasty (25-220).

WTPJ / JTYLX (WS) *Wei taipu ji* 危太樸集 (Collected essays of Wei Taipu). / *Jintong yaolüe xu* 浸銅要略序 (Preface to the 'Important aspects of copper soaking'. In: *Yuanren wenji zhenben congkan* 元人文集珍本叢刊 (Collections of precious literary writings of the Yuan Dynasty), Taipei: Xinwenfeng chubanshe gongsi, 1985.

WX *Wen xuan* 文選 (Selections of refined literature) by Xiao Tong 蕭統, compiled around 520.

WX / Knechtges Knechtges, David R. (1982): *Wen Xuan, or, Selections of Refined Literature*. Princeton, NJ: Princeton Univ. Pr.

WXTK *Wenxian tongkao* 文獻通考 (Comprehensive examination of literature) by Ma Duanlin 馬端臨, 1317.

XHLB / STZJ *Xuehai leibian* 學海類編 (Categorized compilation of the sea of learning) / *Shitian zaji* 石田雜記 (Miscellaneous notes of stone field) by Shen Zhou 沈周 (1427-1509).

XTS *Xin Tang shu* 新唐書 (New Book of Tang) by Ouyang Xiu 歐陽修 et al., 1060.

XZ *Xunzi* 荀子, written in the Warring States period (475 BC- 221 BC).

XZZTJ *Xu Zizhi tongjian* 續資治通鑒 by Bi Yuan 畢沅 (1730-1797)

XZZTJCB *Xu Zizhi tongjian changbian* 續資治通鑒長編 (Extended continuation to the Comprehensive Mirror to Aid in Government) by Li Tao 李燾 (1115-1184)

YJ *Yi jing* 易經 (Book of Changes), c. 1000 BC.

YJ / Legge - Legge, James (1882): *The Sacred Books of China. The Texts of Confucianism. The Yi King.* Oxford: Clarendon Press.

YJS *Yuejueshu* 越絕書 (End of the kingdom of Yue) by Yuan Kang 袁康, East Han dynasty (25-220).

YJS / Milburn - Milburn, Olivia (2010): *The glory of Yue. An Annotated Translation of the Yuejue Shu*. Leiden: Brill.

YL *Yi li* 儀禮 (Book of etiquette and ceremonial), edited in the early Han dynasty.

YL / Steele - Steele, John (1917): *The I-li, or, Book of Etiquette and Ceremonial*. London: Probsthain.

YS *Yan shu* 鉛書 (Book of Yan[shan]) by Ke Zhongjiong 柯仲炯, 1618.

YSJ *Yang Shi ji* 楊時集 (Collected works of Yang Shi [1053-1135]).

YSXZ / JJ *Yanshan xianzhi* 鉛山縣志 (Gazetteer of Yanshan district) compiled during the Jiajing reign-period, 1525.

YSXZ / QL *Yanshan xianzhi* 鉛山縣志 (Gazetteer of Yanshan district) complied during the Qianlong reign-period, 1743.

YSZ *Yisi zhan* 乙巳占 (Yisi prognostications) by Li Chunfeng 李淳風, written around 656.

YTL *Yan tie lun* 鹽鐵論 (Discourses on salt and iron) by Huan Kuan 桓寬, 81BC.

ZGC *Zhanguo ce* 戰國策 (Strategies of the Warring States), compiled between 3rd and 1st century BC.

ZL *Zhouli* 周禮 (*Rites of Zhou*), appeared in 2nd century BC.

ZQG *Zhangquan gao* 章泉稿 (Draft of Zhangquan) by Zhao Fan 趙蕃 (1143-1229), *Siku quanshu* version 四庫全書本.

ZSJN *Zhu shu jinian* 竹書紀年 (Bamboo annals), the original text was interred with the king of Wei (died 296 BC) and re-discovered in AD 281.

ZTDZ / DFJY *Zhengtong daozang* 正統道藏 (Taoist patrology in the Zhengtong reign-period in the Ming Dynasty [1436-1449]) / *Danfang jingyuan* 丹房鏡源 (Mirror-origin of the chamber of the elixirs), written ca. 758-762, partly preserved in chap. 4 of *Jia geng zhibao jicheng* 甲庚至寶集成 (Complete collection on the ultimate treasure made of lead and mercury, *jia*[= real mercury] and *geng* [=real lead]), in ZTDZ, *dongshen bu* 洞神部, *zhongshu lei* 眾數類, 369.

ZTDZ / LHHDJ *Zhengtong daozang* 正統道藏/ *Longhu huandan jue* 龍虎還丹訣 (Instructions on the reverted elixir of the *dragon* and *tiger*) by Jinlingzi 金陵子, written ca. 686-741 or 758-760, in: ZTDZ, *dongshen bu* 洞神部, *zhongshu lei* 眾術類, 590.

ZTDZ / SSLSF *Sanshiliu shuifa* 三十六水法 (Methods of the thirty-six aqueous solutions), date and authorship unknown, probably Eastern Han (25-220), in: ZTDZ, *dongshen bu* 洞神部, *zhongshu lei* 眾術類, 369.

ZZ *Zhuangzi* 莊子, finished in the middle to late Warring States period (475 BC- 221 BC) to early Han.

ZZH *Zuo zhuan* 左傳 (Chronicle of Zuo) by Zuo Qiuming 左丘明, written at the end of the Spring and Autumn Period (771 BC-403 BC).

ZZT *Zhengzitong* 正字通 (Correct character mastery) by Zhang Zilie 張自烈, 17th century.

ZZTJ *Zizhi tongjian* 資治通鑒 (Comprehensive mirror to aid in government) by Sima Guang 司馬光, 1084.

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HYDCD *Hanyu Da Cidian* 漢語大詞典 (Comprehensive Chinese word dictionary) (2002). Hongkong: Shangwu yinshuguan.

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