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"Strong Liquid" from the Western Ocean: Introduction, Manufacture, and Applications of Nitric Acid in Ming-Qing China (1620s–1780s)

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Abstract: Nitric acid or *qiangshui* 强水 ("strong liquid," from lat. *aqua fortis*) was introduced to China multiple times by European missionaries during the Ming and Qing dynasties. Xu Guangqi 徐光啟 (1562–1633) was the first Chinese to record related knowledge from his communication with Johann Schreck (1576–1630). Johann Adam Schall von Bell (1591–1666), Joachim Bouvet (1656–1730), and Matteo Ripa (1682–1746) independently described the substance to the Chinese in their writings, explaining production methods together with different applications such as separating and assaying of gold and silver, etching of iron or copperplates, and manufacturing of thermometers. This paper focuses on newly discovered Chinese materials, mainly from the *Investigations of the Earth's Interior* (*Kunyu gezhi* 坤輿格致, 1640) by Schall von Bell and his Chinese collaborators, but also from the *Record of Essentials of Inception and Completion* (*Kaicheng jiyao* 開成紀要) by Xu Guangqi. It analyzes different aspects of knowledge transmission processes including the identification of useful knowledge, the purpose of transmission, the sources of European knowledge, and the applied methods of translation and explanation. From these analyses we can better understand the reasons of their failure or success.

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摘　要：硝酸或强水（源自拉丁文 *aqua fortis*）在明清时期由欧洲传教士多次传入中国。徐光启（1562 ~ 1633）在与邓玉函（Johann Schreck，1576 ~ 1630）的交流中，成为中国记录相关知识的第一人。汤若望（Johann Adam Schall von Bell，1591 ~ 1666）、白晋（Joachim Bouvet，1656 ~ 1730）和马国贤（Matteo Ripa，1682 ~ 1746）分别在他们的著作中多次向中国人介绍了这种物质，解释了其生产方法以及不同的应用，如试验金属、分离金银、蚀刻铜铁以及制造温度计。本文利用新近发现的中文史料，以汤若望及其中国同事所著的《坤舆格致》（1640）和徐光启的未刊笔记《开成纪要》为中心，分析了上述知识传播过程的各个方面，包括对“有用知识”的认定、传播的目的、欧洲知识的来源以及翻译和解释的应用方法。通过这些分析，我们可以更好地理解其失败或成功的原因。

关键词：硝酸，耶稣会士，明清中国，知识传播，化学史，技术史

1 Prologue: *Aqua fortis* in Renaissance Europe

Qiangshui 强水[1] (lit. “strong liquid”) is the most widely used of the many translated terms for the Latin word *aqua fortis* in Chinese. It dates to the late Ming dynasty where it first appears in context of an interaction between Jesuit missionaries and Chinese scholar-officials. As this article will show, between the 1620s and the 1780s, European knowledge of inorganic acids was independently transmitted to the Chinese on at least four separate occasions by different actors for different reasons and based on different sources of knowledge. Before the situation in China can be analyzed, it is necessary to examine the perception and knowledge about the production of *aqua fortis* in Europe during the Renaissance period.

What is *aqua fortis*? It refers to nitric acid (chemical formula: HNO_3), a highly corrosive mineral acid, which played an important role in alchemy, chemistry, and crafts such as metalworking or printing.[2] Nitric acid is notable for its ability to dissolve all metals except gold, a property which makes it ideal for the separation of silver and gold. Nitric acid first found its way into alchemist laboratories under a variety of different names. The earliest clearly identifiable description can be found in the so-called Pseudo-Geber corpus originating around 1300, whereas the term *aqua fortis* only

1 In modern Chinese language, *qiangshui* 强水 or 镪水 is a general term referring to “strong acid” and is the common name for the following three: sulphuric acid (chemical formula H_2SO_4), nitric acid (chemical formula HNO_3), and hydrochloric acid (chemical formula HCl). However, from the 1620s until the 1780s, *qiangshui* 强水 referred specifically to nitric acid, not to the common names of the above-mentioned three strong acids (Zhang and Yang 1964, 8). It is the *qiangshui* of this historical period that is the subject of this article, and therefore refers exclusively to nitric acid.

2 For a detailed introduction to nitric acid in history, culture and technology, see Chilton (1968).

first appears later in the German *Buch der Heiligen Dreifaltigkeit* between 1410 and 1417.[3] Within a century, the substance was being applied by craftspeople for different, more practical purposes. As Vladimír Karpenko's research shows, Vannoccio Biringuccio (1480–1539), Georgius Agricola (1494–1555), and Lazarus Ercker (1528/1530–1594) were the three most important metallurgists and leading figures in the spread of nitric acid knowledge in the European Renaissance (Karpenko 2009, 110). Biringuccio's *De la pirotechnia* (1540) was the first account to describe comprehensively the isolation of gold. In the first chapter of Book VIII of this work, Biringuccio describes the preparation of *aqua forte* or *aqua acuta* ("sharp water") from saltpeter and vitriol, or from alum, which was a more expensive ingredient (Smith and Gnudi 1990, 188; Biringuccio 1540, 64r). In Book X of *De re metallica* (1556), Agricola illustrates the parting of gold and silver "by means of *aqua valens*, and by powders which consist of almost the same things as this aqua." Agricola first describes what this "aqua" comprises and subsequently provides ten recipes (Hoover and Hoover 1950, 439ff). He was unlikely to have tested these recipes himself, however, as they were recorded from practitioners or extracted from other written sources (Karpenko 2009, 111). Ercker's *Beschreibung der Allerfürnemisten Mineralischen Ertzt unnd Berckwercks arten* (1574) provides the most detailed contemporary account on the production of both nitric acid and *aqua regia*. Ercker first describes how the basic substances alum and saltpeter are prepared. He includes materials suitable for the reaction vessels, such as glass, clay, or iron, and specifies the conditions for distillation. He then lists two basic recipes for the preparation of nitric acid, which will be detailed later in this article (Ercker 1580, 64v. ff).

It is noteworthy that these three standard works, which encapsulate the knowledge of nitric acid in the European Renaissance era, could be found among the Jesuit book inventory in China during the first half of the seventeenth century. Nicolas Trigault (Chinese name Jin Nige 金尼閣, 1577–1628) had been selected in 1613 to travel to Europe to search for funds, new missionaries, books, and scientific instruments. Together with Johann Schreck (Chinese name Deng Yuhan 鄧玉函, 1576–1630), he successfully brought more than seven thousand Western books to China, which would become the basis of the later Beitang library in Beijing (Golvers 2013, 74). The catalogue of the surviving books in this collection lists only *De re metallica* in a sufficiently early edition (Verhaeren 1949, 203/730), but from a list of book purchases by Trigault in Antwerp, we are not only aware that Biringuccio's and Ercker's works were indeed available in China, but can even trace their journey from Europe to China (Golvers 2018, 174). With these—and later even more—materials at hand, European missionaries could pass knowledge of nitric acid to Chinese scholars more than once in the

3 Much earlier instances of the use of nitric acid or other inorganic acids in India, China, or Egypt are possible but sources remain vague. For a list of multiple early terms for nitric acid and more detailed information, see Karpenko (2009, 106–108).

seventeenth and eighteenth centuries, sometimes in great detail and sometimes in brief. The first attempt to transfer knowledge of nitric acid thus falls into the years after the arrival of Trigault and Schreck in China.

2 Episode one: Johann Schreck and Xu Guangqi (1620s)

In the 1962 publishing of *Hand-Written Notes of Xu Guangqi* (*Xu Guangqi shouji* 徐光啟手跡, hereafter XGQSJ), there exist two previously undiscovered sections, namely "Producing Strong Liquid" (Zao qiangshui 造强水) and "Simple Methods of Vigorous Liquid" (Gangshui jianfa 剛水簡法). Once published, these sections immediately aroused responses from the academic community. Pan Jixing, Zhang Zigao, and Yang Gen launched studies on this, and Pan also performed simulation experiments (Pan 1983, 135; Zhang and Yang 1964, 7–8). They have long been recognized as the earliest clear record of inorganic acids in China.

XGQSJ is believed to be a manuscript of notes written by Xu Guangqi when he was preparing *A Complete Collection on Agriculture* (*Nongzheng quanshu* 農政全書), which was completed around 1628. Therefore, the two sections above should have been written no later than 1628. However, the newly discovered manuscript *Record of Essentials of Inception and Completion* (*Kaicheng jiyao* 開成紀要, hereafter KCJY) provides a new addition to the earliest record of inorganic acid. This manuscript, which was identified as Xu Guangqi's unpublished notes, also contains the two sections mentioned above. Apart from differences in some characters' variants, the KCJY version has a more complete and accurate record than that in XGQSJ (Gong 2017, 56). What is even more remarkable is that preceding these two sections, there is another section in the book entitled "Method of Corroding Iron" (Lan tie fa 爛鐵法):[4]

> Method of Corroding Iron (If you want to carve, use it to corrode the part that you want to remove.)
> One uses spirit (*shaojiu* 燒酒), salt, vinegar, arsenic, and *yigeyaerteniyi* 义蛤亞而特膩亦 to be steamed to make distillates (*lu* 露). One can either draw patterns or write the characters [on iron]. Use [the liquid] as you wish.
>
> Master Deng uses the same part of "green alum" (*lüfan* 綠礬)[5] and "fire saltpeter" (*huoxiao* 火硝) [together]. For each *qian* [of the mixture] one adds one *fen* [i.e., one tenth of a *qian*] of "real sal ammoniac" (*zhennao* 真硇).[6] [One uses] vinegar to dissolve them into liquid. This is named "vigorous liquid" (*gangshui* 剛水). Method of use: Add a little wax

4 Etching iron for the purpose of decoration but also for early prints preceded etching of copper plates in Europe as well, see Metzger (2019, 1–26).

5 Green alum (*lüfan* 綠礬) refers to vitriol or $FeSO_4 \cdot 7H_2O$. For the latter, cf. Needham and Lu (1974, *SCC*, vol. 5, part 2, 172 [77]).

6 This is NH_4Cl or sal ammoniac.

on top of the copper or iron, as thick as paper. Limit the four sides with wax so that it does not leak. Next, write any characters and [draw] any images you like, and carve them with a knife. Next, use "vigorous liquid" and pour it evenly over the surface. After one or two quarters [of an hour], the pattern will be formed. After a day or a night, it will be thoroughly corroded.

If "vigorous liquid" is made with refined "gall alum" (*danfan* 膽礬) [instead of green alum], one removes one part out of ten and adds the same [amount] of [fire] saltpeter. [The reason for reducing the amount of alum in this case is that] by refining the essence (*jing* 精) [of alum] is extracted. (KCJY, 3b)[7]

This interesting passage consists of three parts. The first part describes an unnamed liquid made from five ingredients: in addition to the first four, which are more common, readily available, and well known to the Chinese, i.e., spirit, salt, vinegar, and arsenic, the fifth is apparently a phonetic foreign word of unclear meaning.[8] The distillation of these five components corrodes iron.

The second part of the text describes "vigorous liquid" in detail. First, the ingredients, their proportions, and a brief description of their preparation is given, followed by details of their use, including the use of wax to cover and border the surfaces of copper and iron prior to etching, and the different lengths of time and results of the etching process. It is particularly noteworthy that it is clearly stated that this knowledge was acquired through Master Deng, reasonably presumed to be the Jesuit Deng Yuhan 鄧玉函, i.e., Johann Schreck, who was closely associated with Xu Guangqi.

The third part briefly describes another method of making "vigorous liquid." Unlike the previous method, this one uses sulphate of copper rather than vitriol. The production process emphasizes "refining" and "removing the roughness" to obtain the essence. However, the description, especially expressions like "to be carried in water," are too vague for practical application.

"Method of Corroding Iron" in KCJY deserves much attention. First, judging from the order of the text, this paragraph precedes "Producing Strong Liquid" and "Simple

7 "爛鐵法欲雕刻用之即爛所欲去

用燒酒、塩、醋、砒、义蛤亜而特膩亦，蒸作露。或畫（花）文紋，或寫字。任用。

鄧傅用綠礬火硝等分。每錢加真硇一分。醋化水。此名剛水。用法，于銅鐵上略加蠟如紙厚，四邊用蠟作限，不漏水。次任意寫字畫，皆以刀刻之。次用剛水平傾上。過一二刻，即成文。過一日或一夜，即透爛矣。

剛水。用膽礬煉過。十去一。加硝等分。煉出精。其法以水承之。"

8 A vague estimate may suggest that *yigeyaerteniyi* may be based on a German term, the meaning of *yige* being unclear, while *yaerteniyi* might be understood as a transliteration of *Arznei*, or Middle High German *arzenīe*, also *erzenīe*, which means "medicine, art of healing, remedy, drug, pharmacy." Another possibility could be a Latin phonetic, in which *yigeya* represents a nominative of a noun of the -a declination while *erteniyi* stands for a genitive of a noun of the -o declination. A parallel recipe could not be identified in any European source so far.

Methods of Vigorous Liquid," and therefore may have been recorded at an earlier time, thus also preceding the earliest known historical material on inorganic acids. Second, this paragraph, which is missing from XGQSJ, not only explains what "vigorous liquid" is, providing essential background knowledge for the following section, but also presents three methods of making corrosive acid and illuminates the previously unknown role of Johann Schreck in the dissemination of this knowledge.

The next two introductory paragraphs are better known because of their earlier appearance in XGQSJ. As already mentioned, thanks to the discovery of the KCJY, mistakes and omissions in these two passages have been corrected and supplemented, thus making it more accurately understood today. The complete text reads as follows:

> "Producing Strong Liquid"
> [One prepares] green alum (five *jin*, [for example,] the amount is optional) and saltpeter (five *jin*), and fries the green alum until about one-fifth is lost. The two ingredients are then finely ground together and ready to be used. The next step is to make a cauldron (*guo* 鍋) of iron, the size of which is such that there is still room besides for the medicine [i.e., ingredients]. The mouth of the cauldron is slightly recessed, so that it can hold the passing-tube (*guotong* 過筒[9]). In addition, use a large vessel (*tan* 罈) with a glaze on the inside and outside, which can hold about 40 to 50 *jin* and will not crack. Make the passing-tube from glass (*boli* 玻璃[10]) or porcelain (*ciqi* 瓷器[11]), which fits over the mouth of the cauldron at one end and over the mouth of the vessel at the other. Put the iron cauldron on the charcoal furnace (*lu* 爐[12]). Water is added to the vessel as much as the amount of lost green alum. [For example,] if one *jin* of alum is lost, then one *jin* of water should be added. Then, connect the two mouths of the cauldron and the vessel with the passing-tube, and each is glued and sealed with salt mud (*yanni* 鹽泥). The fire is set up under the furnace, and in the first four quarters of [an hour] a slow fire (*wenhuo* 文火) is used, and gradually a quick fire (*wuhuo* 武火) is added, and the fire is extinguished at the end of the twenty-fourth quarter. Take [the cauldron] up and let it cool down completely. When one opens the vessel, the medicine will turn into liquid and the cauldron will be broken. Put all metals into this liquid, all will be dissolved into liquid, only gold does not transform. If one adds salt to the liquid, then gold will also transform. When salt is added to the liquid in which metals other than gold have been dissolved, they become sand again and sink to the bottom of the liquid. Only gold cannot form sand, if one wants it to form sand, one must use the oil of alcohol and indigo (*jiudian* 酒靛) and use another method to produce it. Shade and dry [the sand] for collection. Use a *qian* or so [of such sand] attached to objects and use fire to burn it and it can penetrate metal and stone. Let it enter the ground; it stops when its strength is exhausted. It should not see daylight.[13]

9 In XGQSJ, *tong* 筒 is written as 筩.
10 In XGQSJ, *boli* 玻璃 is written as 玻瓈.
11 In XGQSJ, *ciqi* 瓷器 is written as 磁器.
12 In XGQSJ, *lu* 爐 is written as 鑪.
13 It remains unclear what this passage is referring to.

Strong liquid becomes ineffective after use. If there are other substances mixed [with alum and saltpeter in the cauldron], it can still be made with the first three instruments, then it will become liquid again, and the dregs will be left in the cauldron. ("Vigorous liquid" and "strong liquid" are one kind of liquid.) It is advisable to place a jar (*gang* 缸) under the holding-liquid-vessel, for fear that if it bursts at any time, the liquid will still be in the jar.

"Simple Methods of Vigorous Liquid"
One can either use sal ammoniac alone to dissolve into liquid or use half of spirit and half of soda essence (*jianjing* 鹻精). (KCJY, 3b–4a)[14]

These paragraphs document how to make strong liquid by distillation.[15] Either in detail or in brief, KCJY describes a total of six recipes to produce inorganic acids. Together with their names, ingredients, and uses, they are summarized in the table below:

Table 1: A summary of the names, ingredients, and uses of six recipes for producing inorganic acids

Term	Ingredient	Application
[not given]	spirit, salt, vinegar, arsenic, *yigeyaerteniyi*	etching iron
gangshui 剛水	green alum, saltpeter, sal ammoniac, vinegar	etching copper and iron
gangshui 剛水	gall alum and saltpeter	
qiangshui 强水	green alum and saltpeter	separating metals except gold
gangshui 剛水	sal ammoniac	
gangshui 剛水	spirit and soda essence	

XGQSJ and KCJY, both of which were not published but only preserved as manuscripts, were not widely circulated, and the knowledge of *aqua fortis* thus failed to spread.

14 "造强水
綠礬五斤多少任意，硝五斤，将礬炒去，約折五分之一。將二味同研細聽用。次將鐵作鍋，約盛葯外尚有空。鍋口稍斂，以承過筒。另用內外有泑大罈一具，約盛四五十斤者，則不裂。以玻璃或瓷器為過筒，一端合於鍋口，一端合於罈口。鐵鍋置炭爐上。罈中加水，如所損綠礬之数。如礬折一斤，則加水一斤也。次以過筒接鍋罈二口，各用鹽泥固濟。爐下起火，初四刻用文火，漸加武火，滿二十四刻滅火。取起冷定。開罈則藥化為水，而鍋亦壞矣。用水入五金，皆成水，惟黄金不化，水中加鹽則化。化過他金之水加鹽，則復為砂，沉於水底。惟黄金不能成砂，欲成砂，必以酒靛之油，别以法製之。陰乾收藏。用錢許着物，火之，可透金石。入地。力盡乃止。不見日乃可。
強水用過無力。或有他物雜之，仍用前三噐製，則復為水，滓留於鍋矣。剛水强水緫一水也。盛水罈下，宜置一缸，恐一時迸破，水猶在缸也。

剛水簡法
或止磠砂化水。或用燒酒與鹻精相半。"

15 For a history of the spread of distillation knowledge and technology in China, see Sun (2022).

3 Episode two: Adam Schall von Bell and the separation of the five metals (1638)

The manuscript *Investigations of the Earth's Interior* (*Kunyu gezhi* 坤輿格致, hereafter KYGZ), which was rediscovered in 2015, is a treatise introducing European knowledge on mining and metallurgy compiled by Adam Schall von Bell during his work at the Calendar Bureau in the last years of the Ming dynasty, after he had completed his work on the calendar reform (Vogel and Cao 2016). The KYGZ, long sought but deemed lost, was before its rediscovery simply regarded as a Chinese translation of Georgius Agricola's *De re metallica*. As research progressed, scholars have discovered that *De re metallica* was not the only source of Western knowledge in the book, and that Schall von Bell made extensive use of other European materials available to him (Jost 2021). This becomes particularly evident in the chapters on "strong liquids."

The content related to nitric acid in KYGZ is mainly concentrated in the second, longest chapter, which focuses on assaying. In the introduction of the relevant methods for different metals, such as silver and gold, strong liquids are repeatedly mentioned, but the most detailed and systematic account is given in the last two subchapters under the headings of "Methods with Strong Liquids" (Qiangshui fa 强水法),[16] and "Separating the Five Metals" (Fen wujin 分五金) (KYGZ, chap. 2b, 16b–19a).

With more than two thousand characters, the section "Methods with Strong Liquids" describes in great detail the implements and devices, materials and methods used for their production, in sequence. The description in this sub-chapter of the KYGZ relies clearly on Lazarus Ercker's *Beschreibung der Allerfürnemisten Mineralischen Ertzt, unnd Berckwercks arten*. The text is used selectively, resulting in a description which is not always fully comprehensible and omits many explanatory passages and thoughts. Ercker's work, which was first published in Prague in 1574, does not appear in Verhaeren's catalogue, but can be found on a list of books acquired by Trigault in Antwerp in 1616/1617 (Golvers 2018, 174).

The text begins with a description of various utensils including furnaces (*lu* 爐), different vessels (*guan* 礶) to contain materials and collect distillates (*lu* 露), and different implements (*qi* 器) to regulate the size and heat of the fire. The most important device is, certainly, the furnace. The furnace can be round or square, a large furnace with two or three smaller furnaces connected horizontally, or just one furnace divided into several

16 KYGZ, chap. 2b, 10b–16b. The translation of the KYGZ will be published as a separate volume by Prof. Dr. Hans Ulrich Vogel, Dr. Cao Jin, and Sabine Kink, MA, with the assistance and/or contributions of Dr. Alexander Jost, Prof. Dr. Beatriz Puente Ballesteros, Sebastian Demuth, MA, Dr. Edward Yong Liang, Dr. Ailika Schinköthe, and Prof. Dr. Christine Moll-Murata. This labor division and work flow is reflected when quoting translations of the KYGZ text, and is done in the following ways: Kink (trans.), Vogel & Cao (rev. & ed.); Cao (trans.), Vogel & Kink (rev. & ed.); Puente-Ballesteros (trans.), Vogel, Cao & Kink (rev. & ed.), etc.

layers, with different firing methods depending on their different modes of operation. Schall von Bell tirelessly describes the sizes, shapes, openings, components, and so forth of the various furnaces, making it easier for the readers to conceptualize their construction. In addition, references in the text show his intention to insert an illustration in which the various parts of the furnaces should be clearly labelled. Thanks to his detailed description, this illustration can be easily identified as one in Ercker's book (see Figure 1), and allows us to retrospectively visualize the intended illustration with its labels. It is the only illustration in the KYGZ which is not based on Agricola.

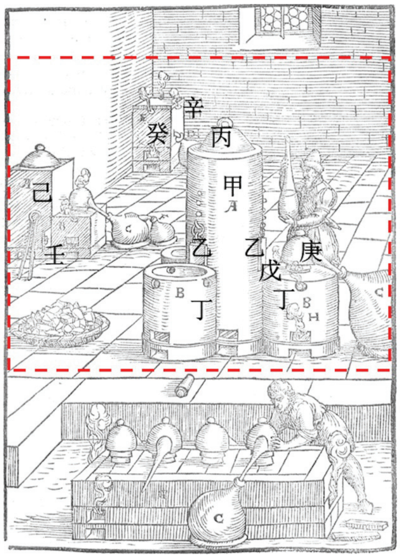

Figure 1: Illustration about the distillation of *aqua fortis* by Ercker with Chinese legend markers indicated in the KYGZ text.[17]

As for the vessels for containing materials and the vessels for collecting distillates, Schall von Bell believes that the selection and handling of the substitute raw materials are of vital importance. Both types of containers are made of glass in the West, whereas in China there is a lack of such material and therefore alternative materials like earthenware or iron must be used instead. Earthenware needs to be glazed, and a certain thickness of the iron is required as well. At the same time, because these alternative materials do not have the transparency of glass, the speed of distillation cannot be observed, creating a greater need to regulate the fire and observe the time carefully.

In introducing the ingredients for making "strong liquids," Schall von Bell summarizes that different strong liquids (*ge qiangshui* 各强水) consist of different ingredients, including saltpeter and the two alums (*fan* 礬) green and white, as well as

17 Illustration from Ercker (1580, 70v). See also Jost (2021, 78).

salt (*yan* 塩) and stringent substances (*liwu* 厲物) emitted inside the mines (*kuangnei suo chu* 礦內所出) (KYGZ, chap. 2b, 13b). He then emphasizes that he is making a liquid, namely "metal-separating liquid" (*fenjinshui* 分金水), that would dissolve all metals except gold, requiring only two ingredients: green alum and saltpeter. This makes it clear that this particular liquid is nitric acid. However, the proportions of the ingredients used, the production time, and the final yield of strong liquid vary depending on the furnaces used. See the table below for details:

Table 2: The proportions of the ingredients used, the production time, and the final yield of strong liquid in terms of different furnaces

	round furnaces and square double-furnaces	square single-furnace
saltpeter	eight parts	eight parts
green alum	nine parts	nine parts
fresh lime	-	six parts
sweet water	as much as green alum's loss during roasting	somewhat less than the left one
duration	one day and one night	six to seven hours
yield	more	less

In the next part, Schall von Bell continues to describe the methods of producing strong liquids in different furnaces. This section ends with a passage on a very crucial material in the distillation process: the lute, the mud that seals the openings of the vessels.

Having described how strong liquids are made, their use—to separate gold and silver from other metals—is the subject of the next subchapter "Separating the Five Metals." Unlike the previous section, which relied essentially exclusively on Ercker's text, this subchapter draws its knowledge from several different books. In addition to Ercker, it also relies on Agricola's *De re metallica* and the *Probierbüchlein*, a German practitioner's guide to assaying ores and metals compiled in the 1560s by Modestinus Fachs (?–before 1595) (Jost 2021, 67).

This subchapter begins by describing how to increase the purity of strong liquid, then goes on to explain how to deal with the three cases of "gold and silver mixed in ore" 金銀相合者, "silver in copper" 銅中有銀者, and "silver in tin" 錫中有銀者, respectively. The paragraphs on the latter two are both excessively abbreviated and distorted versions of the subjects as they exist in *De re metallica*. While the first is still relatively detailed, with its first half based on *De re metallica* and its second half based on the *Probierbüchlein*, a careful comparison of the Chinese text with the original Western sources shows that KYGZ still only provides an extremely abridged account of the process. It is thus difficult to appraise whether the included information would have been sufficient for Chinese readers to successfully reproduce said process.

Yet there is no doubt that Schall von Bell himself successfully applied the method of dissolving silver in nitric acid, which was documented in a fantastical or even magical style by two Chinese acquaintances. The first of these acquaintances is Tan Qian 談遷 (1594–1658), historian and author of an influential history treatise *Discussions about the [Ming] State* (*Guoque* 國榷), who recorded that when he visited Schall von Bell in Beijing on February 18, 1654, he was amazed to witness an experiment demonstrated to him by Schall:

> Tang was also good at "shrinking silver" (*suoyin* 縮銀). He dipped the silver into [liquid] medicine, then crushed it into powder, and would melt it when he needed to use it. Therefore, he had glass bottles, which were as clear as water. [When he melted silver powder,] flowers suddenly appeared [in the glass bottle], which were dazzlingly colorful. This is because the essence of refined flowers was hidden in [the bottle], and it bloomed when it met the medicine. (Tan 1960, 277–278)[18]

In Tan Qian's view, Schall von Bell was performing the art of "shrinking silver," a skill that was widely known as a deceptive trick used by Daoist alchemists (*fangshi* 方士) (Ling 1996, 201). This was in line with the popular belief that the Jesuits were alchemists who understood the arts of yellow [gold] and white [silver] (*huang bai zhi shu* 黃白之術) as well (Cao 2018, 96ff). But beyond the cliché, Tan Qian correctly points out that Schall's experiment with silver was based on knowledge from Western books, two of which—probably Agricola and Ercker—he saw on Schall's shelf, and describes the experimental device (a glass bottle), the material for the experiment (a liquid agent), and the sudden and surprising experimental phenomenon, a flower-like appearance. Through the eyes of Tan Qian, we see an exaggerated and certainly less realistic version of the chemical reaction. In contrast, Schall himself describes the encounter between silver and strong liquid in the KYGZ as the following:

> After having filled a glazed bottle (*liuliping* 琉璃瓶) with strong liquid and thrown then the gold-silver leaves into it, there immediately will be white foam bubbling up. (*KYGZ*, chap. 2b, 17b; Cao & Jost trans., Vogel & Kink, rev. & eds.)[19]

Schall von Bell's other Chinese friend was Fang Yizhi 方以智 (1611–1671). In his *Preliminary Records on the Principles of Things* (*Wuli xiaozhi* 物理小識) he writes of something he calls *naoshui* 硇水:

> There is sal ammoniac liquid (*naoshui* 硇水)[20], if one throws sheared silver pieces into it, they will soon whirl about in the water. Pour it into a basin, [and the silver will] follow the shape [of the basin] to determine [its own shape], and then take the sal ammoniac

18 "湯又善縮銀。淬銀以藥，隨末碎，臨用鎔之。故有玻璃瓶，瑩然如水。忽現花，麗艷奪目。蓋煉花之精隱入之，值藥即榮也。"

19 "以强水注琉璃瓶內，投入金銀葉，即有白沫滚起。"

20 *Nao* 硇 is a variant of *nao* 硇. This is sal ammoniac (NH_4Cl). The character is usually used as *naosha* 硇沙 in phonetic resemblance to e.g., Persian *nushadir* or Sanskrit *nao sadar*.

> liquid and return it to the bottle. The method of obtaining sal ammoniac liquid is to burn a long tube with glaze in a kiln to extract the vapor by smelting sand. Mr. Daowei[21] told me about this. In the year of *gengchen* in the Chongzhen reign [1640], he presented a book titled *Kunyu gezhi* talking about the affairs of mining and separating the five metals, which saves labor and makes much profit. In the year of *renwu*, Mr. Ni Hongbao,[22] who became the Minister of Revenue, also voiced his disapproval of this, but the government did not listen to him. (Fang n.d., chap. 7, 10a)[23]

This entry gives another name for the new inorganic acid applied, namely, "sal ammoniac-liquid" (*naoshui* 硇水). The usage of the word indicates that particular emphasis is placed on the sal ammoniac component. However, there is no information on how exactly to prepare sal ammoniac-liquid, other than to point out the necessity of a long, glazed tube. The value of this account lies in the fact that Fang Yizhi explicitly states that this was learned from Schall von Bell, and mentions the presentation of the KYGZ, as well as the opinions of its opponents and of the imperial court, thus suggesting that knowledge of sal ammoniac-liquid must have been documented in the KYGZ book. This passage had been widely cited and explored by scholars before the reappearance of KYGZ, but since the book went undiscovered for so long, research remained speculative in nature. The word "sal ammoniac-liquid," notably, does not appear in the book of KYGZ. As mentioned earlier, Schall von Bell, in the introduction of the raw materials for producing various strong liquids, said that in addition to saltpeter and green and white alum, there are also salt (*yan* 盐) and stringent substances (*liwu* 厲物) emitted spontaneously inside the mines (*kuangnei suo chu* 礦內所出), and in his preface to the book clearly pointed out that sal ammoniac belonged to the category of salts. From this we can see that to Schall von Bell, "strong liquids" had a broader meaning as a general term for inorganic acids.

It is worth adding that Fang Yizhi's above-mentioned record has attracted the attention of both contemporary and future Chinese scholars, leading to visible reception in later works, for example: the author of *Record of the Spirit of Money* (*Qianshen zhi* 錢神志, completed in 1645), Li Shixiong 李世雄 (1602–1686) (1871, chap. 1, 28b), the astronomer and mathematician Jie Xuan 揭暄 (1613–1695) (1765, chap. 6, 27a), as well as physician and pharmacologist Zhao Xuemin 趙學敏 (1719–1805) (1871, chap. 1, "Water Part" [Shuibu 水部], 7b).[24] Under the entry "Strong Liquid," Zhao (1871, chap. 1, "Water Part," 7a) quotes Fang Yizhi, who stated concisely and confidently: "This *naoshui* is in fact just

21 Daowei 道未 was courtesy name of Schall von Bell.

22 Ni Yuanlu 倪元璐 (ca. 1594–1644, *jinshi* of 1622), whose style name was Hongbao 鴻寶, was a high-ranking official, calligrapher, and painter and Ming loyalist.

23 "有礦水者，剪銀塊投之，則旋而為水。傾之盂中，隨形而定，復取硇水歸瓶。其取硇水沽，以瑠璃窰燒一長管以煉砂取其氣。道未公為余言之。崇禎庚辰，進坤輿格致一書，言采壙分五金事，工省而利多。壬午倪公鴻寶為大司農，亦議之，而政府不從。"

24 This will be discussed in more details later.

strong liquid; it is only that ancient and modern names are different."

Zhang Zigao and Yang Gen (1964, 7) point out that sal ammoniac-liquid is *aqua regia* produced by adding sal ammoniac to nitric acid, while Pan Jixing (1983, 136) suggests including the possibility that it could also be hydrochloric acid, obtained by distilling sal ammoniac with green alum, into consideration. In any case, the episode remains related to an inorganic acid likely based on nitric acid and shows that such substances produced from Western methods were received with great interest by Chinese observers.

4 Episode three: Joachim Bouvet and the thermometer (1690s)

The wars and turmoil of the Ming and Qing dynasties plunged China into unprecedented chaos, and the book KYGZ was lost and forgotten during this period—along with it, of course, the knowledge of strong liquids it included (Vogel and Cao 2024, 146). Nitric acid was not mentioned again until after the Qing dynasty's rule was firmly established and the Kangxi Emperor became interested in missionaries from the West and Western scientific knowledge.

In the Bibliotheca Apostolica Vaticana, there is a Chinese manuscript on the structure, functions, and underlying principles of the liquid-in-glass thermometer. It was titled *Explanations of the Cold-and-Hot Meter for Verifying Qi* (*Yanqi hanshu biao shuo* 驗氣寒暑表說) and must have been a textbook that the Jesuits, most likely Joachim Bouvet (Chinese name Bai Jin 白晉, 1656–1730), compiled and used to instruct the Kangxi Emperor (Shi 2012, 203).

In one method of making thermometers, a so-called "mighty liquid" (*xiongshui* 雄水) is used. The author explains,

> Mighty liquid is the miraculous dew that is generated when two kinds of mineral, saltpeter and alum, are smelted by fire. Power of the liquid is able to dissolve the five metals, therefore, it is called mighty liquid. One puts a thin piece of copper foil into the mighty liquid, consequently, the copper dissolves at once and the water turns green. The reason for not using ordinary water, but exclusively using the mighty liquid, is because it does not freeze in winter and is not easy to vaporize.[25]

It is clear from the ingredients and the production process that this "mighty liquid" is undoubtedly based on nitric acid. However, the liquid used in thermometers must meet three criteria: It had to be pure, non-freezing and of a beautiful color. Therefore,

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25 I am grateful to Han Qijin 韩奇金 for making me aware of this historical information as well as sharing her translation of the text. The translations in this article have been altered somewhat from those of Han Qijin and Shi Yunli.
"雄水乃火煉硝二種所出之~~水也。名曰~~神露也。此水力能溶化五金。故曰雄水。今將箔銅一片。入雄水內。其銅即化溶。而水變為綠色矣。不用平常之水。而專用雄水者。以其冬不凍。并難散渙故也。~~礬用青礬~~"

the liquid in the glass tube could not be colorless nitric acid, but rather the solution obtained by dissolving copper foil with nitric acid.

Although the introduction of the thermometer to the Qing court was short-lived and did not have a major impact or become known to the Chinese intellectuals, this record still demonstrates that in the early years of the Qing dynasty, Western missionaries once again articulated the knowledge of nitric acid to the Chinese, this time as a material with which to produce a solution for application in a scientific instrument. However, the description of its production as well as the terminology used suggest that this instance of knowledge transfer must have taken place without awareness of earlier attempts.

5 Episode four: Matteo Ripa and the copperplates (1711)

After more than twenty years without being mentioned, nitric acid was once again introduced to the Qing court, this time as a necessary ingredient in the production of copperplate engravings.

Interest in this topic stemmed from the Kangxi Emperor's need for engraved maps. After the Jesuits, mainly French Jesuits, had been ordered by Kangxi to carry out large-scale land surveys, the engraving of maps became a priority. The emperor therefore asked the newly arrived missionaries Matteo Ripa (Chinese name Ma Guoxian 馬國賢, 1682–1746), Teodorico Pedrini (Chinese name De Lige 德理格, 1671–1746), and Franciscus Tilisch (Chinese name Yang Bingyi 楊秉義, 1670–1716), whether they—in addition to music, mathematics and painting—also had other skills. Pedrini and Tilisch answered no, while Ripa (1855, 66) said he also knew "something of optics, and also the theory, though not the practice, of the art of engraving on copper with aquafortis." The emperor was highly pleased to hear this and immediately ordered him to apply the technique.

Ripa soon began to experiment on a copper plate coated with lampblack. He painted a landscape with a pointed needle in preparation for etching. As the painting turned out to be to the emperor's taste, he delightedly ordered a Chinese painter to paint a Chinese-styled landscape, and Ripa was required to engrave and draw it accordingly. When this painting was finished, the emperor was even more pleased and surprised, for he found the copy to be very similar to the original, and without any loss. It was the first time the emperor had witnessed the technique of copperplate etching.

However, this was only a preparation for the subsequent etching process, and the actual utilization of the nitric acid followed almost a month later. Because Kangxi was about to leave for the summer palace in Jehol, Ripa was ordered to accompany the journey. As he was leaving, Ripa was injured from falling off his horse and required seven days for his recovery, thus causing delay. After twenty days of travel, the next day after arriving at Jehol, Ripa attended an audience before Kangxi, and the emperor immediately asked him to complete the etching of the copper plates, highlighting the emperor's urgency in this matter.

In fact, Ripa knew little about the art of engraving copperplates, having learned this technique in a single lesson while in Rome. He first needed to find the ingredients to make *aqua fortis*: strong white wine vinegar, verdigris, and sal ammoniac. He described the problems and compared the materials he could obtain in China to those in Italy:

> The sal ammoniac could be procured in abundance, but the verdigris was greatly inferior to ours, and the vinegar, not being made with grape wine, but with sugar and other articles, was not fit for my purpose. Thus, owing to the inefficiency of the *aquafortis*, the lines were very shallow, which, added to the badness of the ink, caused the prints to be of the worst possible description. It cost me no small amount of labor before I could bring this kind of engraving to any degree of perfection. (Ripa 1855, 70–71)

Among the three ingredients, sal ammoniac was the least problematic. Chinese vinegar, which is made of rice, wheat, millet, sorghum, or a combination thereof, generally contains 3–5% of acetic acid (CH_3COOH), while in Europe the wine vinegar is made from red or white wine, containing normally no less than 6% acetic acid. Chinese vinegar could not satisfy Ripa's needs. Lastly, verdigris is a collective term for any of a variety of somewhat poisonous copper salts of acetic acid, which range in color from green to a bluish-green depending on their chemical composition (Kühn 1993, 131–158). It is not possible to determine exactly which verdigris Ripa used, but it is speculated that after returning to Beijing from Jehol, he could have continually improved his ingredients to increase the concentration and potency of the *aqua fortis*.

After Ripa, other missionaries and their Chinese cooperators continued to work on copperplate engraving. Although there is unfortunately a lack of historical records on how they produced nitric acid, the success of its production and use at the Qing court is undoubtedly confirmed by the copperplate engravings that appeared successively in later years. During the Yongzheng reign in 1723, Jesuit Ferdinando Bonaventure Moggi (Chinese name Li Boming 利博明 or Li Baiming 利白明, 1684–1761) from Florence completed the first copperplate star map, the *General Star Atlas of the Ecliptic Double Hemispheres* (*Huangdao zongxing tu* 黄道總星圖) (Han 1993, 388). The Qianlong Emperor's interest in copperplate printing greatly surpassed that of his grandfather and father. In 1765, Qianlong ordered the victory in the Pacification of Dzungars and Muslims to be visualized in copperplate engravings and prints by European craftspeople. These copperplate engravings caused widespread appreciation and influence after they arrived at the Qing court, which in turn launched imitation and reproduction by Chinese painters and engravers of the Imperial Household Department (Neiwufu 內務府) no later than 1770, under the guidance of Jesuits such as Michel Benoist (Chinese name Jiang Youren 蔣友仁, 1715–1774) (Han 1993, 395–396), Ignaz Sichelbarth (Chinese name Ai Qimeng 艾啟蒙, 1708–1780), Louis Antoine de Poirot (Chinese name He Qingtai 賀清泰, 1735–1813) (Nie 2012, 86–87), and François Bourgeois (Chinese name Chao Junxiu 晁俊秀 or Zhao

Jinxiu 趙進修, 1732–1792).[26] These works include the Qianlong imperial atlas (Han 1993, 395), sixty-two paintings of battle scenes in six groups, including sixteen paintings of *Battle to Subdue Jinchuan*, twelve of the *Battle to Subdue Taiwan*, sixteen of the *Battle to Subdue Miao Borderland* (Nie 1980, 64), and the plan of the Old Summer Palace, all of which were completed using the technique of etching (Yan 2019, 52). It must be noted that etching copper plates was a time-consuming task. For example, it took four engravers six months to produce a single copper plate.[27]

6 Sequel: From copper etching to medical uses

The engraving and printing of copperplates in Beijing by European missionaries undoubtedly made many Chinese people aware of this technology, and of the key element in this technology: nitric acid. As a result, nitric acid finally appeared for the first time in accounts by contemporary Chinese people. Zhao Xuemin 趙學敏 (1719–1805) in his *Supplement to Systematic Materia Medica* (*Bencao gangmu shiyi* 本草綱目拾遺) records the following:

> Strong liquid, made by Westerners, is the most violent in nature and can corrode five metals. Mr. Wang Yitang says: "This liquid is so strong that it can penetrate all eight stones and five metals, but can only be stored in glass. The method used by Westerners to make strong liquid involves only seven ingredients, which are boiled together in a pot. This is similar to the method used today to collect dew, with a glass bottle placed next to the pot, and the gaps between the two are sealed. The pot is then repeatedly heated using both a high and low heat, alternately, until black vapor is seen entering the glass bottle, along with water droplets. The process is complete when the black vapor has disappeared, and the strong liquid is fully formed. Due to its strong nature, it is not suitable for oral consumption. If a Westerner wants to paint a Western-style painting, he must first paint the copper plate with a brush, either landscapes or figures, and then soak the area with this liquid for a day and night. The soaked area will rot away, which is better than engraving, no matter high or low, hidden or prominent, everything is depicted well and vividly. If there is any part of the copper that one does not want to corrode, protect it with yellow wax first, and then apply the etching. After a round period [i.e., one day and night], if one sees any signs of corrosion, wash off the strong liquid with sweet water, wipe off the wax, and then the

26 In his letter to Delatour, Bourgeois reported the following, "It was three years ago, Sir, that the emperor wished to have the picture of his European buildings constructed at the Yuanmingyuan to put them together with those of his Chinese palaces, which had been laid out according to his orders. He called upon two or three disciples of Brother Castiglione; they worked, in effect, under the eyes of this Prince who often corrected their views, then he had them engraved on copper, and this is the first example of the Chinese talent for engraving. By way of the two painters who were students of Castiglione, I ended up acquiring a copy of the plates that I am sending you. [. . . One] had begun to render the first plate in color, but he fell ill and did not finish. I have put his sketch, as unfinished as it is, into the case." See Finlay (2018, 129).

27 Archive of Imperial Household Department, date "twentieth day of the sixth month in the forty-third year of Qianlong period" [1778/7/13], quoted from Nie (2012, 86–87).

> copper plate painting is complete. It is absolutely superior to engraving, and is easy and quick." If used in medicine, its *qi* is extracted and used.
>
> It can cure boils and abscesses. Xie Tianshi says, "boils, whether they have burst or not, can be treated with strong liquid, which can eat away the bad flesh and is better than sal ammoniac. One only needs to put the strong liquid in a glass bottle and hold the bottle mouth against the abscess for a short while, and the medicinal *qi* will rise up to the affected area. The abscess will turn white and rot, the poison will be drawn out, and then other medicines can be applied to treat it. If the abscess has roots, this treatment method can also be used, and the roots will rot out." (Zhao 1871, chap. 1, "Water Part," 7b)[28]

There are two important aspects to note. First, this passage is recorded in a medical compendium, thus the recorder's starting point of interest is the medicinal function of strong liquid. Second, before its medicinal properties were introduced, the initial attribute of strong water—its function for copperplate etching—was described in detail, which demonstrates the popularization of knowledge as described by Bian He (2017, 287).

Now let's trace how Zhao Xuemin, a doctor from Qiantang 錢塘 county, Zhejiang, learned about the strong liquid used by the workshops of the Imperial Household Department for the production of copperplate etchings. According to Zhang Zigao's research, there is a mistake in the recorded name Wang Yitang 王怡堂. It should be written Wang 汪 instead of Wang 王, and Wang Yingshao 汪應紹 (1753–?), a fellow-countryman from Qiantang of Zhao Xuemin, while Yitang 怡堂 would be his style name (Zhang 1962, 106–109). Wang served as magistrate of Daxing 大興 County in Beijing from 1783 to 1787, an important position that involved "handling the affairs of the Imperial Household Department and various offices of different ministries."[29] As mentioned earlier, this was exactly the time when the Chinese first attempted copperplate etching, so Wang had the opportunity to observe this process close-up. In addition, records show that he interacted with missionaries and visited the Xuanwumen church or Nantang, admiring the Western paintings in it. According to Wang's friend Zhang Taifu's 張太復 records in his personal *biji* (notes), *Qiuping xinyu* 秋坪新語 (New Words from Qiuping [style name of Zhang]), in the first month of the fifty-first year of the Qianlong reign (1786), Wang Yingshao went with Zhang, a certain

28 "强水，西洋人所造，性最猛烈，能蝕五金。王怡堂先生云：'其水至强，五金八石皆能穿漏，惟玻璃可盛。西人造强水之法，藥止七味，入罐中熬煉，如今之取露法，旁合以玻璃瓶而封其隙，下以文武火叠次交煉，見有黑氣入玻璃瓶中，水亦隨氣滴入，黑氣盡，藥乃成矣。此水性猛烈，不可服食。西人凡畫洋畫，必須鏤板於銅上者，先以筆畫銅，或山水人物，以此水漬其間一晝夜，其漬處銅自爛，勝於雕刻，高低隱顯，無不各肖其妙。銅上有不欲爛處，先用黄蠟護之，然後再漬，俟一週時，看銅有爛痕，則以水洗去强水，拭淨蠟迹，其銅板上畫已成。絕勝鐫鏤，且易而速'云。入藥取其氣用。

治癰疽拔疔。謝天士云：'凡癰疽已潰或未潰，用强水可蝕惡肉，勝於硇砂，只須置强水於玻璃瓶內，以瓶口對癰疽上，掩少時，其藥氣自昇入患處，疽肉變白而腐，毒亦拔出，然後再敷他藥治之。疔有根，亦以此治法，則根自爛出。'"

29 *Neige daku dang'an* 內閣大庫檔案, 030470.

Mr. Yang, a palace physician, and Guan Jinzhai 觀近齋, a Manchu instructor, to visit the church, where they were warmly received by José-Bernardo de Almeida (Chinese name Suo Dechao 索德超, 1728–1805), Director of the Directorate of Astronomy. Zhang describes in great detail the interior decoration and layout of the church, and in particular the lifelike wall paintings. Upon their departure, the Chinese visitors were each presented with a snuff bottle as a gift (Zhang 1795, chap. 3, "Paintings of the Catholic Church" [Tianzhutang hua 天主堂畫]). From this we see an interesting case of knowledge dissemination and its information channels: from the Jesuits to the etching artisans in the Imperial Household Department, whose work was observed by the officials in charge of the household, who in turn were part of a social network that included people with different knowledge backgrounds, such as Jesuits, Manchu Confucian instructors, and Chinese imperial physicians. The imperial physician's knowledge of the medicinal properties of strong liquid may have further promoted the spread of this newly known substance in folk medicine.

However, the use of strong liquid to treat boils and abscesses seems to predate the above-mentioned dissemination of knowledge about copperplate etching considerably. The medical prescription mentioned in Zhao Xuemin's text is attributed to a certain Xie Tianshi 謝天士, which is most likely a mis-transcription of Ye Tianshi 葉天士,[30] who also went by the name Ye Gui 葉桂, as Tianshi was his courtesy name. He was a famous medical scholar from Jiangsu. As it is known that he lived from 1667 to 1747, strong liquid may have been understood and used in medicine as early as the first half of the eighteenth century.

7 Concluding remarks

Knowledge about production methods and applications of inorganic acids were transmitted to China by European missionaries at least four times throughout the seventeenth and eighteenth centuries. It appears that the participants of each transmission instance were ignorant of respective earlier instances. This indicates that at least the first three attempts neither succeeded in widely disseminating and sustainably establishing knowledge about inorganic acids in China, nor initiated a successive process in which the involved missionaries could have built upon earlier efforts.

The reasons for the relative failure of earlier transmission attempts are as multiple as to the contexts of transmission. Four determining aspects must be considered: (1) The practical purposes and motivations for the knowledge transmission, (2) the origins of knowledge in European books or practitioners' hands, (3) the methods of translation and explanation including the appropriate consideration of materials unknown or

30 There are seven references to medical prescriptions by Ye Tianshi/Xie Tianshi in the *Bencao gangmu shiyi*, with five written as Ye and two as Xie. Considering the similarity in pronunciation of the two characters, Xie is most likely a miswriting for Ye.

unavailable in China, suggestions for their replacement, and the establishment of a suitable terminology, and (4) the dissemination of knowledge and operation of methods by Chinese proponents resulting from transmission.

The first occurrence, of which we only know from an unpublished manuscript, was part of a process of collecting curious and possibly useful European techniques by an individual, though influential, Chinese Scholar, Xu Guangqi. This was in cooperation with a well-learned European Missionary, Johann Schreck, at a moment when the extent of available European books was still limited. As no explicit practical purpose was served, it is not surprising that the attempt left no enduring results.

The second attempt was part of the large-scale KYGZ project upon imperial order, which was carried out inside the walls of a state institution and aimed at the production of a printed book for systematic dissemination and application for the final purpose of improving the country's output of precious metal and thus increasing state revenue. Nitric acid would have served the purpose of separating gold from silver and improving assaying methods. Translation work was carried out by Adam Schall von Bell and his collaborators with detail and care for the specific challenges regarding the naming and use of materials unknown in China. Eventually, however, the turmoil of dynastic change undermined this plan. In the following years, conditions for a successful continuation of the transfer process were absent due to political and social instability.

The third instance—the application of nitric acid colored by the addition of copper as anti-freezing liquid inside a thermometer—appears to have been successful for its particular purpose. Because the thermometer itself never became a popular item in seventeenth- or eighteenth-century China and the brief description of the production of nitric acid thus did not enter any more widespread circulation, the reach of this attempt remained confined to the court and the production of a few thermometers.

The fourth attempt aiming at the introduction of copperplate printing by means of etching in China had to contend with difficulties at first as well. Matteo Ripa had to rely on his own practical knowledge and his initial endeavors were not very successful. The Kangxi Emperor, however, remained personally involved. Future emperors maintained a strong interest in copperplate prints and agreed to invest sufficient means in their creation as well as in the exchange with European experts both inside and outside of China.

The centuries-long history of European attempts to transmit knowledge about the production of inorganic acids to China is an example which proves that a sustainable, complex technical knowledge transfer process relies on a multitude of conditions for its eventual success or failure. This begins with the identification of a useful technology and continues with the existence of a substantial motivation, together with sufficiently influential proponents supporting them. It requires a reliable source of knowledge and a translation or explanation included with this source which considers the particular Chinese situation, as well as subsequent, ongoing support where necessary and exchange with competent participants on both sides. In the case of the strong liquids, in earlier instances, some of these conditions went repeatedly unfulfilled, causing these attempts to fail and their transmitted information to disappear.

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