Revisiting the Bocarro Cannon Foundry in Macao

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ABSTRACT: Allowing that no additional 'smoking gun' document has come to light, this article seeks to revisit some of the early literature on the cannon foundry established in Macao (c. 1627–1650) by Manuel Tavares Bocarro to expose gaps in our understanding as well as to encourage further research in this area. In line with recent historiography, the article acknowledges technological exchange in weaponry across Eurasia as opposed to an absolute European priority from the sixteenth century. As argued, this is amply demonstrated by the Portuguese–Ming China technology exchange such as contracted in Macao. As also demonstrated, the exchange was not confined to China but extended also to Japan and Vietnam under the southern Nguyễn dynasty at their request.

KEYWORDS: Bocarro; Cannon foundry; Gunpowder; Technology exchange; Portuguese–Ming relations.

INTRODUCTION

Although well attested in literature, as with the early writings of historian Charles Boxer, surprisingly, very little advance has been made over the decades in the study of Macao's early seventeenth-century cannon foundry. More legendary than validated and standing outside of local archaeological research, our knowledge gaps extend to a deeper study of the technology employed in the production process in Macao including the sourcing of copper, iron, tin, and other key elements necessary to produce iron or bronze cannon, not to mention acquiring the associated elements to produce gunpowder. The Bocarro Cannon Foundry was established between c. 1627 and 1650 by Manuel Tavares Bocarro, a scion of the Bocarro family of cannon-makers established in Old Goa in India (and with Tavares Bocarro going on to serve as Captain-General and Governor of Macao from 1654 to 1664), the period also coincided with existential threats to the *status quo* in Portuguese-administered Macao posed by Holland in mounting a series of albeit unsuccessful seaborne attacks on the city.[1] Stated another way, whereas in the past the Ming authorities had restrained the Portuguese from building defensive walls and positions, the new conjuncture led to close collaboration in defending Macao and even the empire in facing down armed attacks by the eventually victorious Manchus.

Located astride the historic Praia Grande (Nam Van) on the Macao Peninsula adjacent to the Bom Parto Fortress and the slope of Penha

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Fig. 1: Bilingual street signage as described by Padre Manuel Teixeira. Photo by author, Macao 2024.

Hill, the historical site has been identified in part with the space today occupied by a children's park. Known locally as Chunambeiro or Chunambo, a former source of lime collected from oyster shells, as registered by historian Manuel Teixeira,[2] the site also lent its name to a road still extant, namely Rua do Chunambeiro. With the Chinese characters 燒灰爐 (shaohuilu) denoting 'furnace place', it leads us to enquire as to exactly what kind of furnace, even though the sources and secondary literature are largely silent upon the technical aspects of smelting and casting, not to mention the procurement of gunpowder or its constituent ingredients and manufacture.

As well recorded, Chinese smelting techniques range back 4,000 years. Knowledge of the gunpowder mixture of sulphur, saltpetre, and carbon, dates from the ninth century. Famously, Mongol-era naval forces employing bombards and artillery (albeit not metal-barrelled weapons) mounted punitive raids off southwestern Japan in 1281 and Java in 1283, long before Europe mastered the technology.[3] As exposed by Joseph Needham,[4] there was a time lag of several centuries between the first appearance in China of cannons, bombs, and gunpowder weapons and their reception in Europe, and with many transmissions mediated through the Arabs or during the Mongol ascendancy.[5] With the first Portuguese ships arriving off the coast of southern China (c. 1521–1522) also engaging in naval encounters in the Pearl River Delta, the foreign interlopers who were flushed from their success a decade earlier in capturing the Malacca emporium from its Islamic custodians were obviously curious as to the state of Chinese military technology, whether it was ahead or lagging.

As will be argued, recent historiography has moved towards acknowledgement of technological exchange across Asia as opposed to a sixteenth-century European priority such as entering much of the conventional literature. As Marie-Louise Haller-Fries has demonstrated in an extended essay,[6] reaching back to the Portuguese conquest of Goa in 1510, it is credible that the seaborne intruders also took on board certain innovations resulting from cooperation with indigenous and foreign craftsmen. That would include Indian, Ottoman, and Chinese casting technology innovation, depending upon location. The same author also draws attention to the cannon casting knowledge exchange with China in the Chunambeiro foundry, as well as signalling the seventeenth-century military technology exchange between Portugal and Ming China.

The question as to whether the Europeans had a military-technology advantage over other peoples of the world during the early modern period has also been raised by military historians. As Subrahmanyam and Parker announce in their survey of the European 'military revolution' as it played out in South, Southeast, and East Asia, '[t]he arrival of the Portuguese in the Indian Ocean with their armed vessels around 1500 had already made firearms an important feature in naval warfare there'.[7] Specifically, Tonio Andrade has focused on the so-called Sino-Portuguese War of 1521–1522 or naval encounters proximate Macao to examine this issue.[8] Noting that whereas in the first set of naval engagements of 1521, Portuguese artillery

was markedly superior but in the second set of engagements of 1522, Chinese artillery caused major damage to the Portuguese ships. He found that '[i]f there was still a gap in 1522, it was much smaller', suggesting that the Chinese quickly learned to counterbalance Portuguese firepower. In the case of China, he demonstrates, the rapid adoption of Western artillery continued through the ensuing decades as the Ming redesigned Portuguese-style guns — termed *folangi* or Frankish guns — and adapted them to their own needs.[9]

While there is no evidence that Chinese cannons were technologically inferior to those of the Portuguese, it would appear, however, that European mathematical knowledge associated with gunnery was indeed ahead of the Chinese practice, just as cannons and muskets captured from the Portuguese were closely examined. As Yin Xiaodong explains,[10] between 1506 and 1521 both the breech-loading cannon dubbed Frankish culverin and the musket were introduced in Guangdong and Fujian. They were then copied and manufactured locally using traditional technology. Early in the following century the more complex muzzle-loading or 'Western' cannon also made their appearance whether by capture or purchase. Especially Yin draws attention to the role of Jesuit missionaries in introducing cannon-making technology and knowledge of mathematics which were crucial to perfecting ballistic trajectory as with the use of the gunner's quadrant to determine the elevation of the cannon. Notably, in 1607 Matteo Ricci and his Chinese bureaucrat collaborator, Xu Guangqi (Paul Hsü Kuang-ch'i) interpreted Euclid's *Elements*, also revealing for the first time the relationship between geometry and firearms, a tradition carried on by German missionary Adam Schall von Bell and, in the service of the Qing Emperor Kangxi, by the Belgian, Ferdinand Verbiest.[11]

To be sure, the early modern period in world history — Europe in particular — saw fundamental changes in military ethos as with the introduction of the arquebus progressively embraced through the fifteenth and sixteenth centuries. Neither should we ignore Portuguese naval prowess especially as it entered the Indian Ocean successfully taking on Ottoman and other Islamic adversaries in a number of crucial encounters. As with Macao's historic Mount Fortress, a major feature of Portugal's seaborne 'expansion' was the construction of an arc of fortifications spanning the Indian and southern Atlantic oceans, important if we are to understand the use of artillery in defending conquests not only at the expense of local holders of power but also against European rivals, Holland in particular.[12]

We should look to some context as to the establishment of a sixteenth-century Portuguese 'priority'. As well noted by Brazilian military historian, Adler Homero Castro,[13] in the European Middle Ages, combat by foot or infantry or by horse as with cavalry was directly associated with the nobility. On the other hand, artillery was an activity that required technical knowledge in mathematics, metallurgy, and chemistry, and artillerymen and engineers were seen as members of the scientific arms (*armas científicas*). The Bocarro family of reputed crypto-Jewish Christian converts appeared to fit the mould. According to Teixeira, the Bocarro family were a dynasty of founders which began in Portuguese India in the last quarter of the sixteenth century, with the eldest member Francisco Dias Bocarro, mentioned in 1587.[14] He was succeeded by his son Pedro Dias and his grandson Manuel Tavares. In 1674, the last Bocarro, Jeronymo Tavares, was named literally a 'master of the artillery foundry of the state of India' (*mestre da fundição de artilharia do estado da Índia*). The main Portuguese gun foundry in India was at Old Goa and was for many years under the supervision of Pedro Dias.

Fig. 2: Azulejo painting of oyster harvesting scenes in Parque do Chunambeiro, the original location of oyster harvesting. Photo by author, Macao 2024.

As Boxer explained,[15] the Portuguese technology exchange in Asia was not confined to China but also to Japan with respect to the introduction of arquebuses, castle design as with adaptation of *donjons*, naval architecture and even in the training of a Japanese cadre in cannon manufacture at Nagasaki. Nguyễn Vietnam would also turn to Macao for practical assistance in acquiring cannon as well as their manufacture back home. Although no additional 'smoking gun' document has come to light on the Bocarro foundry in Macao, this article nevertheless revisits some of the early literature on the subject, as well as the Portuguese–Ming technology exchange to expose gaps in our understanding as well as to encourage further research in this area. The first section will discuss the rationale behind the launching of a gun foundry in Macao, the second section addresses the supply of copper and gunpowder to the Macao foundry, the third section discusses Portuguese diplomacy with the Ming apropos of the building and arming of fortifications in the face of threats from the Dutch. In the absence of more concrete historical data, the fourth section turns to the historical evidence with surviving cannons, museums, and museology. To test this argument, we also extend the essay in the way of offering a synthetic account of Portuguese military exchanges with the Ming court to meet the threat of advancing Manchu forces. A conclusion will return to the premise as to the validity of the technological exchange argument as well as the validations of sources.

1. PRETEXT FOR THE FOUNDRY AND MACAO'S FORTIFICATIONS

While, as alluded, the Portuguese had earlier established a gun foundry in Old Goa in India, the procurement of Japanese copper became a matter of urgency in Macao following the first Dutch attacks upon the city commencing in 1601, as the Portuguese needed to strengthen their fortifications and to fortify them with cannons. Such a hitherto forbidden development had the express consent of the Ming, and local officials were well informed as to progressive advances in Macao's fortifications and the local manufacture of weaponry. More than that, as this essay will develop, without direct Ming support in the way of supply of expertise, manpower and vital elements in support of the furnace operation, the foundry could not have been established or maintained.

The pretext for the fortifications of Macao, including the need to cast cannons locally, with the Dutch seeking to enter the China trade directly, has been much panned in the literature going back to travel collections issued in the eighteenth century. Certainly, as Portuguese historian Jorge Graça points out, the development of fortifications in Macao progressed through stages in the early decades owing to the initial reluctance of the mandarins to accept any defence system in the city that could be used as a stage to threaten the mainland. Over Chinese objections, the first artillery batteries commenced to appear c. 1604 but not gaining sanction or momentum until after the major Dutch attack of 1622, especially under Governor D. Francisco de Mascarenhas (1623–1626), who took possession of the St. Paul's Fortress under the control of the Jesuits, and constructed the St. Francis and St. Tiago da Barra batteries, as well as fortifications on Penha Hill and at Guia, among other bulwarks and a connecting system of walls. It was likewise Governor Mascarenhas who launched the Chunambeiro foundry for casting cannons.[16]

Through his study of published accounts including an archival source citing a Dutch commander, we owe it to Boxer for carefully situating Macao's vulnerability to Dutch attacks back to the first failed venture in 1601, repeated in 1604 and 1607, with a major multi-ship invasion on 24 June 1622.[17] As he explained, this was at a time when the Mount Fortress was only partly operative and, as known to the attacking Dutch, also at a moment when Portuguese military specialists were out of Macao assisting the Ming in their defence against the Manchu invasion. With a landing party of some 600 Dutch along with 200 ethnic auxiliaries, this was touch and go in an epochal campaign leading to major losses on the Dutch side and the winning of much 'face' for the Portuguese defenders in the eyes of the Ming. As Boxer alludes, the Portuguese victory also prevented the Dutch from gaining a monopoly on the Chinese and Japanese markets and undercut French and English rivals as well.[18]

According to Nuno Valdez dos Santos,[19] in taking cognisance of the Dutch threat to Macao, King Philip II issued a royal charter (*carta régia*) of 18 January 1607, to proceed with the construction of fortifications, albeit only commenced in 1612 owing to Chinese objection and other obstacles. While different versions of the role of the senior Bocarro and his son in Macao are entertained, as Santos asserts, Manuel arrived in Macao in mid-1625 first serving in the foundry as a young man. By 1626, he had already struck a cannon known as the *Peça dos mandarins*, going on in 1627 to create cannons named after the saints. Besides producing cannons used to strengthen Macao's defences, namely on the Mount Fortress, the Bocarro foundry also cast bells and statues, such as the bell dated 1633 in St. Lawrence's Church, the bell in the chapel adjacent to the Guia Lighthouse

Fig. 3: Diorama of the Bocarro foundry (on display in Macao Museum).

and likely some of the bronze statues at the Ruins of St. Paul's.

To add a contextualising element, Portugal's Dutch rivals likewise hosted a cannon foundry in Batavia. This they followed up in 1611 after setting up a trading house on the island of Hirado off the northwestern coast of Kyushu in Japan. There they began casting mortars and other weapons in large part to impress the Shogunate and to win their tenure at a moment when their Catholic rivals, Portugal, were being expelled along with missionaries. Cannon making was known in the archipelago even prior to the irruption of Europeans, including the Islamic outlier of Manila thanks to Ottoman and other transfers. However, under Spanish rule, Manila not only hosted a cannon foundry but was a supplier of cannon to Macao at least down until the end of the Union of Two Crowns (1580–1640). Still, as Boxer[20] contended, neither the Dutch cannons produced in Batavia nor in other locations in Asia reached the standard of excellence of the Bocarro products, although this is not to deny a general preference for cannons cast in Europe such as those frequently harvested from shipwrecks as with the Tokugawa in Japan and the Nguyễn court in Vietnam.

In the absence of specific sources as to the Bocarro foundry's setup, whether entirely along the lines of the Portuguese Goa foundry or whether hybrid or localised fitting the prevailing Ming technological prowess, we should evaluate accordingly.[21] One thing is for sure with respect to the smelting of ores and that would apply to copper ingots used in the construction of bronze cannons or pig iron used in the construction of iron cannons, was the axiom that no matter how rich the ore deposit (or the foundry in this case), it was useless without sufficient wood in the vicinity used to make charcoal. Such was spelt out in a book by Qu Dajun (1630–1696) on iron smelting in Guangdong. The Macao Peninsula lacked wood and we may take it for granted that charcoal supply for the Bocarro foundry was sourced to interior Guangdong and shipped downriver.[22]

With respect to copper supply, copper sourced from Japan sustained the Bocarro foundry at least until the final prohibition of the nearly century-long Portuguese trade with Japan. Although new sources of copper were tapped in Szechuan (Sichuan) and Yunnan under the Ming, still Japanese copper either arriving directly in Macao via the Portuguese ships or indirectly via the junk trade, made up for a deficit in local supply. More generally, demand for Japanese copper in China increased, just as the Ming switched from paper currency to minted copper coins.[23]

With early sources of iron arriving in Macao from Goa as ship ballast, rich sources of iron were also available locally. Specifically, Luoding County in Guangdong was a major local source of iron, supporting an array of small and large furnaces, some capable of producing 3 to 4 tonnes of pig iron a day. Accessible to the Luoding River flowing into the Xijiang (West River) and on to Foshan, such sources of iron would have been readily available to the Bocarro foundry.[24] For that matter, even modern

vessels could navigate as far as Wuchow (Wuzhou), 290 kilometres from the delta, smaller vessels as far as mineral-rich Nanning, 790 kilometres inland, and local or indigenous craft as far west as the Yunnan border, thus potentially tapping even more distant supplies of iron, copper and tin deposits together used in the production of bronze cannon.[25]

1.1 CANNONRY EXPERTISE/TECHNIQUE

While the basic design of European cannons may appear to be simple, namely an enclosed metal tube with a closed rear end with a small opening on its back from where the shot is made, as Brazilian military historian Adler Homero Castro explains, such a description is misleading because it does not take into consideration the technical demands involved in operating weapons.[26] Namely, if fired under highly elevated pressure it requires considerable technical or empirical knowledge to avoid explosion during usage (and there are multiple examples of such incidents including flawed cannon demonstrations by the Portuguese in Beijing or the Dutch in Japan). Likewise, he explains, the casting of the objects was also intricate, '[e]ach being an individual piece manufactured by using the lost wax (*cera perdida*) casting technique, where the mould is destroyed after the metal is molten, meaning they could not be mass produced'. Certainly, as discussed below, that appeared to be the hallmark of the Bocarro cannons, each carefully individualised, crafted, and embossed or welded with a distinct design or insignia. Finally, and if not obvious, they were very expensive to manufacture (and so required state or quasi-state patronage). As Needham mentions, we should also observe that a typical furnace site in Guangdong employed 200 furnace workers, 200 water carriers and charcoal procurers (aside from miners).[27] If so, then we cannot envisage the Bocarro foundry's operation without such manpower backup and supply chains reaching up the West River as endorsed and facilitated by the local Ming authorities.

No less important for the establishment of a foundry in Macao would have been local Chinese experts in cannonry and foundry operations. This was first revealed by Boxer in 1938 referencing a contract entered into between the Governor of Macao, D. Francisco de Mascarenhas, and two Chinese artisans assigned to cast cannons in Macao.[28] They were named Quinquo and Hiaoxon (Haizon) in an article published by Braga.[29] Writing almost two decades later, as Boxer pointed out, the original contract with the specialists dated to October 1623 then still existed in Portuguese archives in Évora replete with original Chinese signatures.[30] As he elaborated, at the time there was also a demand for Chinese specialists to serve in the gun foundry in Goa noting as well that the art of casting iron was little practised in the Iberian countries. Accordingly, in 1626 two individuals were sent to Goa along with iron ore procured in China via Macao. The request by Goa for more Chinese specialists was repeated in March 1632 although the quality of the iron ore was also queried. It is important to note, as Boxer sets down, that these individuals were specialists in casting iron cannons and that the art of casting iron cannons in Macao originated from the Chinese side. On the other hand, the founding of bronze guns in Macao owed to Portuguese inception. But were the two named Chinese mere artisans or were they masters of casting? Were only two individuals contracted or were they accompanied by their entourages? Or were they joined by successors as the years progressed? More recently, Tonio Andrade has engaged in this issue, asserting that Ming innovations in adopting iron and bronze composite metal casting techniques were sufficiently effective to prompt the Portuguese to seek out Chinese gunsmiths for their cannon foundries in Goa, with technology transfer in mind.[31]

2. THE STRATEGIC MATERIALS

From its foundation in 1587 by the Portuguese and the Jesuits arriving from Macao, Nagasaki, located in the southwestern part of Kyushu in Japan, became a thriving port, especially in the silk-for-silver trade with Canton (Guangzhou) as the source of silk.[32] Until the Jesuits and the Portuguese were expelled in 1637–1642, the relationship was profoundly transformative both in Japan and Macao. First, the trade enriched Macao, or individuals in Macao, as it did in Japan. It brought waves of Japanese exiles to Macao and, crucially for the Portuguese, the silver used to pay the ground rent as demanded by the Ming.

2.1 COPPER AND TIN

While Japanese copper alongside silver may well have comprised an import into Macao from an early date on the part of the Portuguese as well as Chinese junk traders, it is not well documented. As Boxer revealed from his scrutiny of Portuguese documents, Japanese copper only formed an important item in the last years of the Macao–Japan trade and was directly connected with the Bocarro foundry.[33] Boxer's major source on copper imports into Macao is a lengthy document produced by the incoming Viceroy of Goa, D. Miguel de Noronha, Count of Linhares. According to a letter of 16 November 1629, a meeting of the Council of State decided to auction three Japan voyages to the highest bidder. The contract was duly given to Lopo Sarmento de Carvalho on the condition that he delivered 1,200 *piculs* of Japanese copper at the end of each voyage at a set price (one *picul* equals to 60–64 kilograms). Owing to the conditions in Nagasaki relating to the debts owed by Portuguese merchants under the so-called financial bond system (*respondência*),[34] the first of Sarmento's three ships would not arrive in Nagasaki until July 1632. In dispatches written by Sarmento in December 1633, he claimed to have brought back in full to Macao the two years of copper supply as contracted, leaving a surplus in Macao.[35] Altogether, as Boxer interprets, Sarmento's voyage provided a total of 4,000 *piculs* of copper used to supply both the Bocarro foundry in Macao and Goa.[36] Still, with the Dutch running a blockade on the Strait of Malacca this was no easy matter. In the event, with a truce signed with the English in 1635, English shipping — notably the *London* — was used to freight Japanese copper and several of Bocarro's bronze cannons from Macao to Goa. As Boxer clarifies, Macao's cannon industry was so important that regaining access to Japanese copper was one of the chief objects of the (failed) official Portuguese embassy of 1647.[37] By this date, copper exports from Nagasaki began to dramatically expand to the benefit of the Chinese junk traders and the Dutch East India Company (VOC) merchants, albeit lost to the Portuguese.[38]

It is also worth noting that back to at least 1600, the cargo manifests of the Portuguese Great Ship to Japan also included the import of tin, an important ingredient in the bronzing of the cannon and with bronze, an alloy of copper and tin.[39] Still, we may assume that Malacca was a prime Portuguese source of tin up until the Dutch conquest of 1641, just as the Malay Peninsula has long been known for its tin deposits. But, as revealed by Japanese records of a Chinese voyage of 1685, even with the Dutch in control, junk traders continued sourcing tin from Malacca, variously touching ports in the Pearl River estuary, Xiamen, and Meizhou Island (northeast of Quanzhou) en route to Nagasaki.[40] Likewise, inland regions of China close to waterways made Macao accessible to Chinese sources of tin if required.

2.2 COPPER FROM VIETNAM

Historical sources also allude to copper from Vietnam being sent to Macao to produce cannons. At the beginning of the seventeenth century, the

southern Nguyễn with their capital in Huế sought to maintain its artillery superiority in defence against attacks mounted by northern Trịnh dynasty's rivals and with Vietnam standing out on mainland Southeast Asia for its relatively advanced casting technology along Chinese lines. In line with the above, it is known that in 1651 the Nguyễn sought to send copper to Macao so that the cannons could be manufactured there. Certainly, this fits the peak of production of the Bocarro cannon foundry. It also coincides with the period prior to the perfection of cannon casting techniques in local Nguyễn foundries such as those established at the imperial capital of Huế.[41] At issue for the Portuguese was not only the security of the Catholic missionaries, but also fierce competition with the Dutch who had also muscled in on trade with both the southern Nguyễn and the northern Trịnh.[42]

As exposed by the late Macao historian Benjamim Pires[43] citing a document sourced to the Ajuda archives in Lisbon, commencing during the monsoon of July–August 1651, Macao entered into contractual relations with the southern Nguyễn through the exchange of gifts. At the time, João de Sousa Pereira, Captain-General of Macao (1650–1654), wrote to Nguyễn Phúc Tịn, the ruling Nguyễn Lord (1648–1687) who completed the conquest of the Champa Empire and whose reign also coincided with the end of the Nguyễn–Trịnh wars, requesting permission for the missionaries to reside in his kingdom. He also sent him a cannon as a gift. This was delivered by two Macao-based missionaries, Metello Sacanno and Pero Marques. In return, the king sent a gift to the captain-general and promised to accept the missionaries. At the same time, he wrote a letter to the Jesuit visitor Sebastião da Maia (1650–1651), in which he thanked him for his letter and gifts and offered him gifts in kind, also pledging to send copper to be cast into cannons. Specifically, he requested the captain-general to have the cannons forged and delivered up to himself by the missionaries on their return journey. Only then would he sanction a permanent presence of the missionaries. First translated into Portuguese by the Jesuits in Macao, and subsequently rendered into English as it first appeared in *Review of Culture*, the royal document reads as follows:

> ***I, King of the Kingdom of Cochin-China, am writing this letter to the Captain-General of the City of Macau.***
>
> *[…]*
>
> ***I am sending five thousand catties of copper. Trusting in your esteem, I ask you to have it cast into cannons. I will consider this a great favour which I will never forget because, although they could be cast in my land, I wish to have them cast in Macau due to the trust I place in you. […]***
>
> ***You may have the guns I need cast to your liking, either large or small, provided that you use up all the copper. This favour will be as great as the mountains and shall remain in my heart like the waters that descend from the same slopes.***
>
> *[…]*
>
> ***Written in the third year of my Reign on the twenty sixth day of the third Moon of the year sixteen hundred and fifty one.***[44]

As Pires relates, more requests for artillery from Macao followed. Still, the delay in shipping enraged Nguyễn Phúc Tịn, leading him to take some reprisals against the Faifo (Hoi An)-based missionaries. In short time, Pero Marques made

letter contact with Macao and the requests were immediately met. In 1659, a ship belonging to João Vieira conveyed the heavy artillery to Annam with the missionaries' rights restored.[45]

While we may surmise that there was cross-border copper trade with Yunnan just as the copper deposits in that vast region were then being exploited, we cannot rule out that the provenance of the copper pledged by the Nguyễn monarch was Japan. Certainly, by this date, VOC's ships commanded sanctioned exports of Japanese copper including those struck as coins, a trade item in high demand in mainland Southeast Asia. Vietnamese sources also allude to the existence of a foundry in Huế headed by the Portuguese master cannon maker João da Cruz, with European methods of casting larger ordinance replacing local technology.[46] By the time Cruz died in 1682, the Nguyễn were producing most of their cannons locally and in large numbers.[47]

2.3 GUNPOWDER

As alluded, gunpowder was a Chinese invention produced from the three key elements of sulphur, saltpetre (potassium nitrate) and carbon (charcoal) only borrowed by Europeans in the Middle Ages. Still gunpowder production was subject to much experimentation as to the ratio of the ingredients employed. But we should also be cognisant that there was no one standard of charcoal. Rather, as modern research confirms, it was a major variable in gunpowder manufacture depending upon the type of wood and the production process, with harder woods optimum.[48] Citing a Chinese source dated 1584, Needham reveals not only that willow was the chosen charcoal in China but that the proportions to be used in the manufacture of gunpowder were, saltpetre 75.6 percent;[49] sulphur 10.6 percent; and charcoal 13.7 percent.[50] What this suggests is that a great deal of experimentation and adjustment was implied in borrowing or copying European cannons and matching gunpowder mixes.[51] As acknowledged by Garrett, besides importing most of their gunpowder from their larger mill operation in Goa, a small gunpowder mill was also established in Macao (although this requires more research).[52]

Neither can we ignore the other ingredient used in gunpowder manufacture, namely saltpetre. According to Mascarenhas, the main source of saltpetre used in gunpowder manufacture in the Portuguese territories was the Indian Peninsula as traded at ports in Gujarat, Bengal, and Coromandel.[53] With charcoal universally available, as Sun points out, saltpetre played a more important role than sulphur and charcoal in the gunpowder formula especially as it had to be traded long distance.[54] Not only was saltpetre known in China from antiquity practically as naturally occurring, but it was also manufactured and widely traded. Besides China, Tokugawa Japan also produced saltpetre, with the industry growing exponentially after the introduction of European matchlock guns in 1542. This was especially the case during the rule of the Kaga domain in Gokayama, a mountainous area astride the Japan Sea on Honshu.[55] Intriguingly, as Petrucci has revealed, there was also a trade in saltpetre from Macao to Japan.[56] This is set out in a 1567 letter from the Otomo family of Bungo, a powerful warlord (*daimyo*) in northwestern Kyushu, known for purchasing weapons and gunpowder from the Portuguese, to Bishop Belchior Carneiro in Macao requesting a monopoly on the import of saltpetre from the city, at the rate of ten *piculs* a year. Again, this is little studied from a Macao perspective, and we know less about how the Portuguese sourced the key elements required to produce high-quality gunpowder, saltpetre included. Neither can we preclude that the Portuguese also looked to the Ming to supplement their stock of the black powder during critical junctures.

What then was the Portuguese state of knowledge of gunpowder production? With copper casting and working of great antiquity on the Iberian Peninsula, foundry technology was also well developed in early modern Portugal as was the production of gunpowder likely introduced by the Arabs in the thirteenth century or even earlier. According to the research conducted by Quintela, Cardoso and Mascarenhas,[57] the first known mention of gunpowder makers belongs to the reign of King Afonso V (1438–1481), as well as the first provisions for storing gunpowder, and with the first documented evidence of gunpowder factories in Portugal dating to the reign of King Manuel I (1495–1521). At the Barcarena plant in Lisbon, four gunpowder mills were finished in 1618. Each had an edge runner that moved on a bed around a vertical shaft, driven by an overshot wheel. In the first half of the sixteenth century there were known units in India as in Goa at Terreiro do Paço and Divar Island, and at Chaul and Bassein. In Brazil, the first manufacturing units were established in the major captaincies during the sixteenth century and installed at Salvador da Bahia and Rio de Janeiro in the following century. The Azores, Ceuta, Oman, and Macao would be added to the list. But the major operation in Asia was at Goa, built at the expense of the national treasury near Goa, in Panelim, during the government of Viceroy D. Francisco da Gama. It was finished in 1630 by Viceroy D. Miguel de Noronha, Count of Linhares and is often described as a derivative of its Barcarena ancestor. The output of this factory satisfactorily met the demands by all the Portuguese fortresses of eastern Africa and Asia as well as private requirements.[58]

Still, once the Portuguese had arrived in East Asia, they surely had to take stock of local technologies, especially those connecting with naval encounters and mounting coastal defences. With respect to sulphur, volcanic islands in the Ryukyu

Fig. 4: Ming artillerymen from a mural in Yanqing District, Beijing. Wikimedia, https://en.wikipedia.org/wiki/Gunpowder_weapons_in_the_Ming_dynasty.

Archipelago were one source tapped by Chinese traders dating back to the time of the Southern Song dynasty. According to Yamauchi's study of the sulphur trade between Japan and China in the Song and Yuan periods, Iojima(硫黄島), a volcanic island in the northern Ryukyu Archipelago, emerged as a major source, also connecting with Fujian.[59] As Yamauchi surmises, as an essential military material, the sulphur produced on the island may have played an important role in the initial stage of establishing political and economic relations between sovereign authorities in Ryukyu and the Ming dynasty. Solor offshore Timor in the eastern Indonesian Archipelago was another source of saltpetre and sulphur for

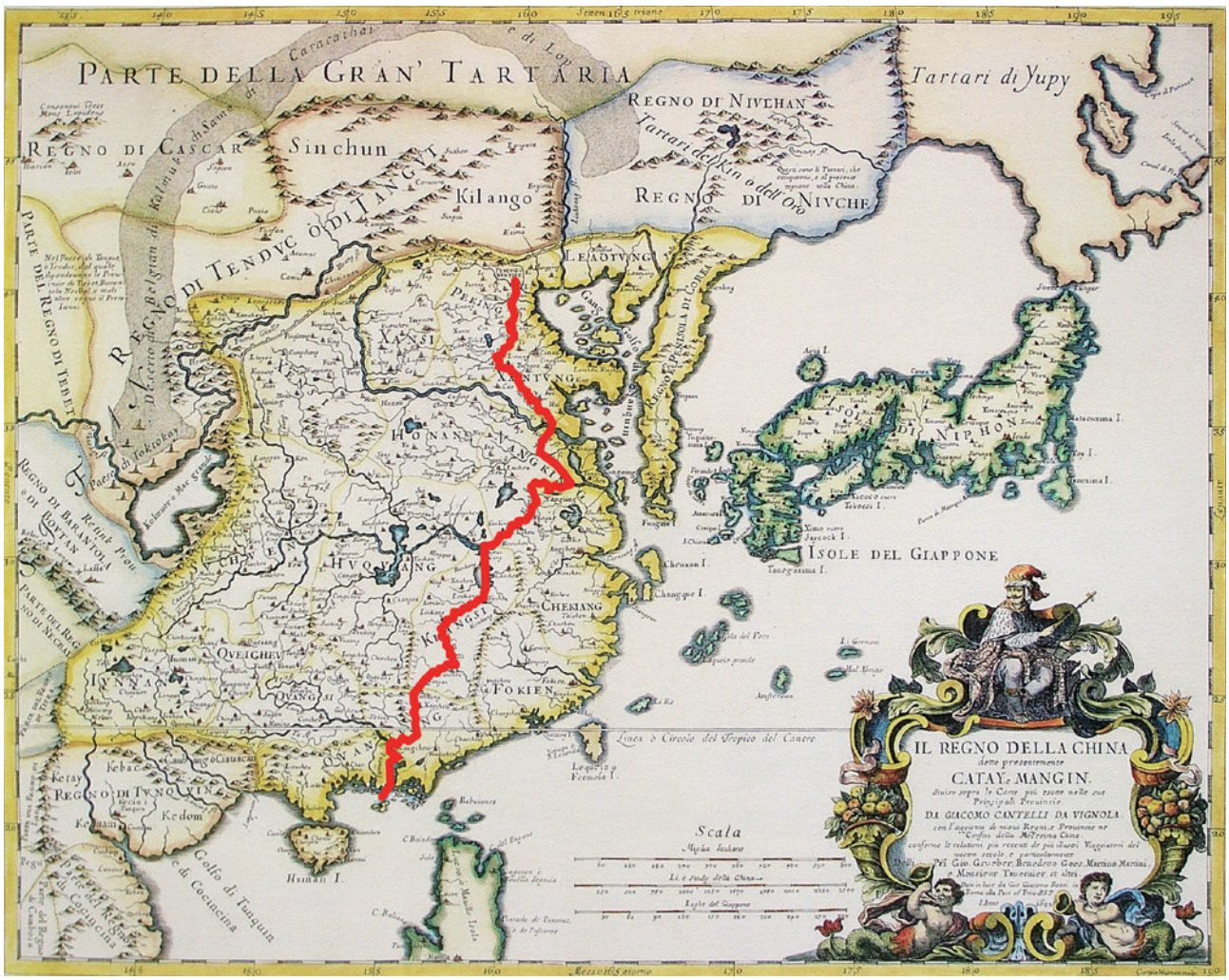

Fig. 5: Matteo Ricci's route from Macao to Beijing, more or less followed by Gonçalo Teixeira Correia in the 1620s and 1630s. Map by Giacomo Cantelli, Giovanni Giacomo de Rossi, 1682. Wikimedia, https://en.m.wikipedia.org/wiki/File:Matteo_Ricci%27s_way_from_Macau_to_Beijing.jpg.

both the Portuguese and Chinese, at least until it was taken over by the Dutch.[60] Although less well documented, the Island of Java was also connected with China in the sulphur trade.

3. PORTUGUESE DIPLOMACY WITH THE MING

Besides the traffic in Bocarro's cannons across the maritime routes reaching the Indian Ocean littoral or even Europe, there is another dimension to the Macao foundry and cannonry expertise, namely diplomacy. Importantly, as discussed below, with the Portuguese gaining a permanent foothold in Macao, the Ming would solicit direct assistance from Portuguese cannon experts especially when the dynasty came under threat from Manchu forces. Just why the Ming would turn to Portuguese cannons as opposed to their own developed over a long historical period is explained in an essay by António Graça Abreu, with recourse to Chinese texts.[61] As he explains, from the moment of the first Portuguese arrival on the coast of China, the Ming

coastal defences were severely tested in various sea battles, leading to the capture of several Portuguese cannons. Closely studied, and duly impressed, the Ming looked to reinvigorate their coastal defences including cannonry, especially as China's own precocious development of cannonry had stagnated over the centuries.

First made known to Europe by Portuguese missionary Álvaro Semedo in a book published in 1642, the City of Macao duly responded in 1630 by offering some 400 officers and regular soldiers. However, having made the arduous voyage as far as the provincial capital (Nanchang) of Jiangxi, they were informed that their services were no longer required.[62] Also drawing upon Semedo's account, Boxer[63] was undoubtedly pioneering in placing Semedo into a historical perspective with his chronology of events (slightly edited) as reproduced below. Modern research mostly confirms these events with the writings of Jorge M. dos Santos Alves[64] who asserts that Macao sent seven diplomatic missions to the Ming authorities between 1611 and 1633, including the one of 1611 seeking permission from the Guangdong provincial authorities to build fortifications in the city. Historian Michael Cooper[65] explains in some detail the dispatch of a mission at Chinese request from Macao in November 1628 bearing seven bronze and three iron cannons accompanied by João Rodrigues 'the translator'. Under the command of artillery captain Gonçalo Teixeira Correia, the battle-tested party triumphantly entered Beijing in February 1630. There they received imperial support to request a follow-up mission from Macao as the Manchu threat was by no means diminished.

3.1 TIMELINE OF PORTUGUESE MILITARY MISSIONS IN SUPPORT OF THE MING

1620	Matteo Ricci's Christian convert Xu Guangqi proposed using Portuguese cannons against the Tartars.
1621	Four guns and bombardiers were sent from Macao (though the bombardiers were turned back).
1623	Board of War memorialised the Emperor to favour Portuguese gunners.
1624	Seven Portuguese gunners arrived in the North, one of whom, João Correa, was killed in an accident.
1628–1630	Expedition of Gonçalo Teixeira Correia and Antonio del Campo went from Macao to Nanchang, Jiangxi Province, where the majority was sent back.
1631	Teixeira died in the defence of Tengchow (Dengzhou).
1643	One cannon and four gunners were dispatched from Macao to Canton and Nanjing at the request of Cantonese provincial authorities.
1646	Nicolas Ferreira and 300 men joined Southern Ming Emperor Yongli.
1647 (March–July)	Successful defence of Kweilin (Guilin) by Ferreira.
1650 (November)	Final Manchu capture of Canton.[66]

Boxer[67] is astute as well in acknowledging that, with their long traditions of cannonry, the Ming authorities looked to Macao not only for the physical cannons but to take advantage of the superior Portuguese knowledge of gunnery (and this is testified by the transmission of the science of ballistics such as introduced by the Jesuit interpreters).

4. THE HERITAGE

Writing from Macao during the war years, J. M. Braga[68] announced that among the hundreds of bronze and cast iron cannons produced in Macao, the vast majority had been lost in shipwrecks or melted down. He also recalled that, besides their use in the defence of Macao, a number of cannons produced in the Bocarro foundry were found being used in the actions against pirates on the China coast, sent as gifts to, variously, the Chinese emperors as well as the kings of Portugal, with others dispersed to Portuguese settlements in Africa and Brazil. Not only were the Bocarro cannons used against pirates, but occasionally pirates also used captured cannons in their battles.[69] As Boxer adds, during a later period, Portuguese settlements and outposts such as Solor, Flores and Timor were mainly supplied with cannons from Bocarro's gun foundry in Macao.[70]

As Braga[71] earlier pointed out, although specimens of Bocarro's cannons had been reported in various museums, there were then no examples extant in Macao. Today, the few surviving examples of these cannons are kept in the museums in South Africa, Oman, Lisbon, London, and Kagoshima in Japan. As bronze-worked cannons, they are impressive for their attention to aesthetic detail, and some are embossed with the coat of arms of the City of Macao. They are also renowned for their size (with some cannons weighing up to 3,026 kilograms and 3 metres long), not to mention their prowess that greatly attracted the interest of the Ming who looked to mount their own defences and military campaigns.[72]

Notably, a bronze artefact cast by the Bocarro family's foundry in Macao was salvaged in May 1977 from the wreck site of the Portuguese galleon *Santíssimo Sacramento* which ran around near Schoenmakerskop in present-day South Africa on her maiden voyage in 1647. In that year the Portuguese galleons *Santíssimo Sacrament*o and *Nossa Senhora da Atalaia do Pinheiro* departed from Goa with a cargo of Bocarro cannon which was intended as a gift from the Viceroy of India to John IV, the King of Portugal from 1640 to 1656. Weighing about 4 tonnes with a length of 3.7 metres, this cannon is one of the few remaining examples of its type in the world. It is decorated with the coat of arms of the Portuguese administration in Macao and the monogram of the Governor of Portuguese India.[73] Also to note, the National Museum of Oman holds a falconet — a kind of artillery piece that was very effective against infantry — that was made in 1643 in Macao by Bocarro. Inscribed are the words '*Viva el rei do Joao IV*' (Long live King John IV), the name '*Macau*', and the words '*encaza da polvra 1643*', referring to when the piece was made and the kind of ammunition it used. According to a press piece, a National Museum spokesperson described the weapon as 'richly decorated with acanthus leaves on the muzzle, barrel and breech, while the handles are designed to look like Chinese-style lions'.[74]

On the other hand, the Bocarro cannon curated in the Shoko Shuseikan Museum in Kagoshima is dedicated to the Shimazu clan heading up the Satsuma domain in southern Kyushu, and it is likely, as viewed by the author, a falconet, and not without aesthetic features. Although studied in some detail by Japanese researcher Muto Chozu[75] with black and white photographs, the enigmatic inscription on the cannon, namely '*De Ant Soares*

Fig. 6: *Si Jagur* Cannon at Fatahillah Square. Photo by CEphoto, Uwe Aranas. Wikimedia, https://commons.wikimedia.org/wiki/File:Jakarta_Indonesia_Si-Jagur-Cannon-at-Fatahillah-Square-03.jpg.

Vivas', was only deciphered by Boxer.[76] As revealed, the name corresponded to Antonio Soares Vivas, a Spanish officer and merchant based in Macao, who commissioned the Macao foundry to cast the cannon. With Boxer dating the cannon to c. 1630, he thus contradicted Muto's assertion that it was acquired in a battle against a rival Christian *daimyo* during the previous century. While the provenance of the cannon thus remains obscure, we can believe that, in the hands of the powerful Shimazu clan, the cannon became an enduring local trophy.

Two Bocarro cannons survive in the British Royal Armoury collection, one in the Tower of London named *St. Ildefonso* and the other named *St. Lawrence* housed in Fort Nelson, Portsmouth. According to a British Royal Armoury description, 'the *St. Ildefonso* cannon was returned to this country from China in 1842' (following the capture by the British during the Opium War). Dated 1627, it is described as of large calibre containing a chambered bore. The piece's name, *S. Tilafoco* (probably *St. Ildefonso*), is engraved at the muzzle. The arms of Portugal are displayed in relief with the cross of the Order of Christ surrounded by the inscription '*da cidade do nome de deos da China*' (of the city of the name of the God of China). Below is a scroll bearing the name of the founder and the date '*Manoel Tavares Bocarro afes a 1627*'. As noted, the gun fired a stone shot weighing about 30 pounds. *St. Lawrence*, the larger of the two cannons, boasts a Portuguese coat of arms supported by angels, one raising aloft the cross and the other a disc-like object. Various

Chinese touches are noted on both cannons. The muzzle mouldings are heavier; the name of the gun engraved in front of the muzzle is '*S. Lovreco*' (St. Lawrence).[77]

Rediscovered in the twentieth century, the *Si Jagur* cannon currently lodged in Fatahillah Square (Stadhuis Plein), the historical centre of Old Batavia (present-day Jakarta), was captured by the Dutch in the siege of Malacca. Esteemed for its potency, over the centuries it became a talisman for locals in Java — barren women especially — seeking its blessing. Made in 1625 by Bocarro in Macao, as described by a Jakarta History Museum website, it was smelted from 16 small cannons and weighs 3.5 tonnes. Emblem of the Bocarro metallurgical craft as much the sardonic temperament of that age, the breech end of the cannon features a finely crafted thumb wedged between two fingers, an obscene gesture used to insult enemies.[78] With some scores of these great bronze cannons produced in Macao, we can hazard that the value added to Japanese copper by the Bocarro foundry helped to capitalise and sustain the operation (although we know next to nothing about financing outside of the lucrative Japan trade). It is credible that specialists were sent from India to Macao to instruct and apprentice Chinese metalworkers.

CONCLUSION

With the Bocarro cannon foundry as the focal point, this article has gone far in exploring the possibilities of Portuguese–Ming China exchanges in weapons technology. From the Portuguese side, such exchange included copper smelting technology, Portugal's own prowess in mounting defensive positions as with the construction of the Mount Fortress, and the often-ignored Jesuit introduction of mathematical ballistics. We cannot conceive of a 'military revolution' on the China coast that could be comparable to the development in Europe. Simply, back to the Song dynasty if not earlier, China was far ahead of Europe in pioneering the essential elements of smelting and casting cannons, not to mention the invention of gunpowder and its use in weaponry. In any case, some early naval skirmishes aside, the small European kingdom and the Central Kingdom were not at war with each other in the late Ming. Rather, circumstances drove them together, in the first instance in countering naval threats by Portugal's European rivals upon China's soft southern coast and, in the second instance, in confronting the no less threatening assault upon the Ming empire itself by the Manchu invaders ushering in a new dynasty, altogether tumultuous events which the Portuguese adroitly survived.

We should not be surprised that alongside the better-studied silk-for-silver trade engaging China with Japan and the America via the Spanish galleon system, stood substantive commerce in what today we would describe as war materials. In this distant age of so-called gunpowder empires, this commerce included, vitally, copper along with tin used in bronzing, secondarily iron ore, along with the essential ingredients to gunpowder manufacture. As this article has exposed, such procurement did not come easily and the sources range from the Japanese archipelago to the Indian subcontinent, to maritime Southeast Asia, just like the shipborne supply routes that were season-prone, hazardous, and wide open to attack by rivals. As revealed, the Bocarro foundry could not have operated without the supply chains that reached the neighbouring districts of China to keep the furnaces running with sources of wood or more likely charcoal, limestone, and other ingredients used in the smelting process, including local (China) sources of both iron and copper alongside the supplies arriving from Japan or Goa. Going beyond the supply of materials, we surmised that the Macao foundry with its preponderant Chinese workforce including foundry

specialists adopted elements of local technology as with furnace or even casting design, also in demand in Goa. It may only be cosmetic, but we cannot ignore that certain oriental or Chinese touches were incorporated into the cannon design that further helped to indigenise the weapons or make them more attractive to local clients.

Another dimension of the Bocarro foundry in Macao as highlighted by this article was the derivative character of the expertise transmitted via the parent Bocarro family in Goa, itself replicating the then state-of-the-art foundry technology and gunpowder mills established in Lisbon in the early seventeenth century. The art of gunnery was an associated skill and appears to have been well-tested in medieval Europe. While space precludes a discussion on cannonry advance in China ranging from bombardments wielded by Mongol attackers in Japan in the late thirteenth century or cannonry exchanges reaching Java or northern Vietnam in the same period, it is remarkable — although not thoroughly tested — that by the late Renaissance Europe and by mid-to-late Ming such parallelism from the opposite ends of Eurasia in weaponry and casting technology would exist such as that either side could draw upon the other in technological innovation or advance in the art of war. Such also fits the contention of Andrade that 'likely that there was a global — or at least Eurasia-wide — process of gradual but consistent acceleration in military innovation during the early modern period, as societies came into sustained contact as never before in history'.[79]

As this article confirmed, the Bocarro cannon foundry was the single most important proto-industrial activity in Macao through the late Ming period and with its cannons traded widely across the region. Surprisingly though, local Macao archaeological research has largely failed to register evidence of the copper smelting and casting process, which otherwise would add further evidence of this activity. However, as local Macao historian João Guedes lamented, the re-discovery, through archaeological research, would be an 'impossible task', as the evidence is forever lost under the foundations of buildings that began encroaching the Chunambeiro neighbourhood in the 1980s.[80] Dating from an earlier age, such buildings include the former premises of the Jardines & Matheson — a reference to the two-storey 'Ricci building' that nowadays houses the 'Estrela do Mar' school — overlooking a reclamation area that did not exist when the seventeenth-century cannon and bell maker worked in the area. RC

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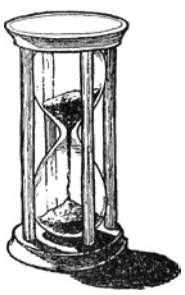

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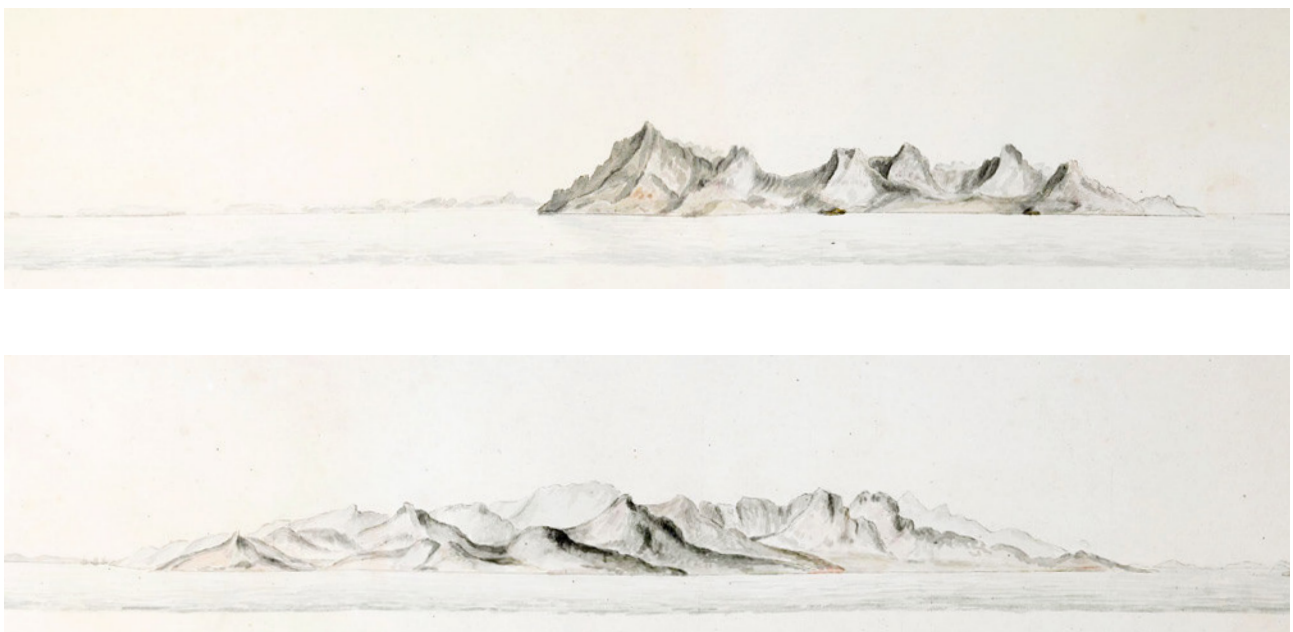

A collection of eighty views, maps, portraits and drawings illustrative of the Embassy sent to China under George, Earl of Macartney, in 1793. British Library, Topographical Collection of George III, Maps 8.Tab.C.8.