METROPOLITAN MUSEUM JOURNAL 58

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ABBREVIATIONS

MMA The Metropolitan Museum of Art
MMAB The Metropolitan Museum of Art Bulletin
MMJ Metropolitan Museum Journal

Height precedes width and then depth in dimensions cited.

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Persimmon and Peonies: Orange-Colored Glass and Enamels from the Qing Imperial Workshops

JULIE BELLEMARE, FEDERICO CARÒ, KAREN STAMM

Amid the growing scholarship on pigments and colorants in China, orange is a color that has so far received little attention. Perhaps it was not as culturally salient as the five colors that formed an important cosmological system and were understood as "primary colors" in classical texts, namely red (*chi*, 赤), blue-green (*qing*, 青), white (*bai*, 白), black (*hei*, 黑), and yellow (*huang*, 黃).[1] Sunzi (孫子; 544–496 BCE), in *The Art of War*, claimed, "There are no more than five primary colors, yet in combination they produce more hues than can ever be seen."[2] The terminology for the color we now associate with orange was in flux during most of China's history, crystallizing only as *chengse* (橙色) or *juse* (橘色), after oranges and mandarins, in the modern period.[3] But the material culture produced during the Qing dynasty (1644–1911)

fig. 1 Small vase. China, Qing dynasty (1644–1911), Yongzheng period (1723–35). Glass, H. 3⅜ in. (8.6 cm). The Metropolitan Museum of Art, Edward C. Moore Collection, Bequest of Edward C. Moore, 1891 (91.1.1174)

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shows several shades of what we would now recognize and call "orange," which are also named in archival records—for instance, we find textiles dyed in "apricot yellow" (*xinghuang*, 杏黃), or painting pigments obtained from minerals such as realgar (*xionghuang*, 雄黃) or red lead (*huangdan*, 黃丹).[4] Importantly, orange colors are also found in silicate pyrotechnologies such as glass and enamels.

In 1680, the Kangxi emperor (r. 1662–1722) created a system of imperial workshops specializing in a variety of mediums and object types, from tablewares to weapons.[5] Catering to the material needs of the court, the workshops were overseen by skilled technocrats, and production was controlled by the emperor himself (and later by his successors), who reviewed most of the objects and artworks created in the workshops. A close study of these can illuminate the experimental nature of imperial production, as well as the degree to which this production integrated European materials and techniques brought to China by Jesuit missionaries working at the Qing court. In the early decades of the eighteenth century, the number of colors available to glass and enamel workers increased dramatically, largely due to the Kangxi emperor's insistence on acquiring foreign colorants and expertise, as well as his determination to match—and surpass—these technical achievements at the imperial workshops.[6] The efforts expended to create such a range of colors can be partly explained by Qing emperors' eagerness to outshine their cultural rivals in this artistic arena, and the colorful objects produced at the imperial workshops evinced the technical advances cultivated within the Qing empire, where raw materials were extracted and transformed into highly sophisticated products.[7]

As part of ongoing research for the Met's exhibition *Embracing Color: Enamel in Chinese Decorative Arts, 1300–1900*, enameled porcelain and glass objects from The Metropolitan Museum of Art were selected for scientific analysis. This study focuses on three objects: two opaque orange glass wares—a small bottle from the Yongzheng period (1723–35) and a tripod censer made during the Qianlong reign (1736–95)—as well as a porcelain bowl with overglaze enameled decoration of yellow and orange peonies, also dating to the Yongzheng period (figs. 1, 2, 5). A historical investigation uses archival records and connoisseurial literature to situate these objects within their contexts of production and reception, while scientific analysis considers not only the chemical composition of the glasses, but also how the colors might have been produced. This two-pronged approach helps illuminate the processes of production at the Qing imperial workshops, where experiments with colorants and new materials were actively encouraged, arguing that new orange colors were the product of these experimental approaches. But before delving into these production processes, this article explores the origins of the now commonly used term "realgar glass" to denote opaque orange glass and proposes an alternative, more historically accurate, appellation.

FROM REALGAR TO PERSIMMON

Although scholarly attention to Chinese glass has been growing in recent years, the type of opaque, orange-toned glass commonly known as "realgar glass" rarely benefits from more than a passing mention, and therefore we know very little about how it was made or how it came to acquire this association with the mineral realgar. This category comprises opaque glass colors ranging from yellow to reddish brown, generally with a marbled or mottled patterning, or in rare cases, pictorial surface effects. In the most substantial study of this type of glass, Shelly Xue examined the earliest pieces of "realgar glass" to have entered European collections.[8] Xue reveals records of a bowl and two hexagonal vases collected by Sir Hans Sloane in the 1720s, now in the British Museum, London, and twelve cups that entered the Royal Danish Collection in 1732. Interestingly, these records do not associate the pieces with realgar. Instead, the bowl is described as "A China bason yellow & red made of flints," while the cups are considered "made of prepared agate in China."[9] These descriptions beg the question of whether the term "realgar glass" was used when these pieces were produced, or even when they were collected in the West.

Although a glasshouse was first established in Beijing in 1696 by the Kangxi emperor, workshop archives were only systematically compiled starting in 1723 under his successor, the Yongzheng emperor.[10] These archives are organized by date and workshop, with straightforward descriptions of each commission, as well as production notes chronicling the results. Given the ubiquitous mentions of color or decoration, it is surprising to find not a single mention of realgar in conjunction with glass.[11] While it is possible that the orange-colored glass pieces were simply described as "yellow" or "red," another term is a possible match: "persimmon glass" (*shihuang boli*, 柿黃玻璃), after the bright orange Chinese persimmon (*Diospyros kaki*). The earliest record of this term dates to November 25, 1726, as part of an imperial order for bronze spoons to be paired with glass water containers in red, blue, "persimmon," "clear-sky-after-rain," and white (clear) colors, as well as snuff bottles of all colors.[12] A subsequent order for a persimmon glass bowl was filed in September 1733.[13] During the following Qianlong period, production of persimmon glass increased substantially, with commissions recorded throughout the reign, but with a clear concentration in the 1740s. Among these, a series of orders for persimmon glass bottles for holding incense tools (as part of sets also comprising an incense burner and box) appears to correspond to the small orange bottle in the collection of The Met (fig. 1).[14] This type of diminutive work continued to be produced in the imperial glass workshops during the Qianlong period, as is the case for the incense burner, also in the collection (fig. 2).

Early discussions of Chinese glass in the literature of Western connoisseurship similarly contain no references to realgar. The term is absent from Maurice Paléologue's chapter on Chinese glass in *L'art chinois* (1887), as well as from Stephen W. Bushell's seminal *Chinese Art* (1904–6). In the latter, Bushell provides an illustration of a snuff bottle that would now unequivocally be labeled as "realgar glass," instead describing it as "variegated in colour to simulate tortoiseshell . . . made of red and yellow mottled opaque glass."[15] The association of this mottled opaque glass with realgar might have formed during the following two decades, as the catalogue of the *International Exhibition of Chinese Art*, which took place at the Royal Academy of Arts in London in 1935–36, contains a mention of a "Bowl; glass, imitating realgar" having been exhibited in the Large South Room of the galleries.[16] It is clear from the above discussion that the term "realgar glass" was used neither in China nor in Europe during the eighteenth and nineteenth centuries, but rather is the result of an association that likely emerged among early twentieth-century collectors. While these connoisseurial designations may be difficult to fully dispense with, we propose the term "persimmon glass" for discussing pieces that were produced in an imperial context.

Two objects made of opaque persimmon glass, a Yongzheng-period small bottle and a Qianlong-period tripod censer, were analyzed by noninvasive qualitative X-ray fluorescence (XRF) spectroscopy[17] to determine their chemical compositions and investigate the colorants and opacifying agents used in their creation (figs. 1, 2). It should be noted that the adopted methodology does not allow for an unambiguous identification of all the glass constituents, as some chemical elements could not be detected (such as boron, fluorine, sodium, and magnesium), or can be associated

fig. 2 Tripod censer. China, Qing dynasty (1644–1911), Qianlong period (1736–95). Glass, H. 2⅞ in. (7.3 cm). The Metropolitan Museum of Art, Purchase, The Vincent Astor Foundation and Barbara and William Karatz Gifts, 2020 (2020.334)

fig. 3 Detail of the rim of fig. 2, showing the yellow-to-orange layers

to several colorants, opacifiers, and fluxing agents in the same object (such as arsenic, tin, and lead). Despite these limitations, it was possible to propose glass typologies, colorants, and opacifiers, and to offer clues as to how persimmon glass was produced.

Analysis of the small bottle suggests a composition of lead silicate glass with an arsenic-based opacifier, and with a copper-based colorant. Iron, zinc, and tin X-ray K-lines of low intensity were also detected. Results for the tripod censer have been interpreted as a sodium borosilicate glass[18] with an arsenic-based opacifier and a copper-based colorant. In this case, in addition to traces of iron and tin, the analysis detected traces of lead and antimony, indicating that small amounts of other opaque colorants might also be present, in addition to reducing additives. The different hues of orange present in both objects, from light orange to dark orange, are almost identical in composition, suggesting that the glass used for each object was created from the same batch and that copper was the main coloring agent. Similar results were obtained in recent analyses of Qing-dynasty persimmon glass objects from the Bristol Museum & Art Gallery and the Corning Museum of Glass.[19]

Observation of the cut and polished rim of the tripod censer appears to confirm that the range of warm colors on the objects was indeed not created by mixing distinct colorants, but rather by casing the basic shape with successive layers from the same glass batch (fig. 3). Each cased layer exhibits a color gradation from red at the interior edge to yellow at the outside edge, with a hard distinction between the yellow and red with each new layer. This could likely be explained by the glass being worked in a furnace with a reducing atmosphere. Between each casing, the object was likely exposed to air outside the furnace, resulting in a lighter color, while the interior of each layer remained dark orange. Obtaining the opaque red with a copper colorant requires a strictly controlled and highly reducing system. In oxidized form, copper normally confers a turquoise or green color to glass, depending on the composition of the matrix in which it is mixed. Reduction, through a reducing agent added to the glass, or by a firing atmosphere devoid of oxygen—or both—will reduce the cupric (Cu^{++}) ions either to cuprous ions (Cu^{+}), which could precipitate as crystals of cuprite (Cu_2O) imparting yellow to brick red colors depending on their size, or to nanoparticles of metallic copper (Cu^{0}) with high red coloring power, or both.[20] When the hot glass is being worked, even momentary exposure to oxygen might cause the color to change to orange, yellow, or green. Incidentally, small green specks and thin lines are observable on both of the glass objects in this study, supporting the findings that the colors were created through dispersed metallic copper and, possibly, cuprous oxide particles, resulting from different degrees of exposure to air.

Previous analyses of red and orange opaque glasses from the Ancient Near East have also revealed the common presence of lead and tin in the glass, additives that were detected in the two persimmon glass samples.[21]

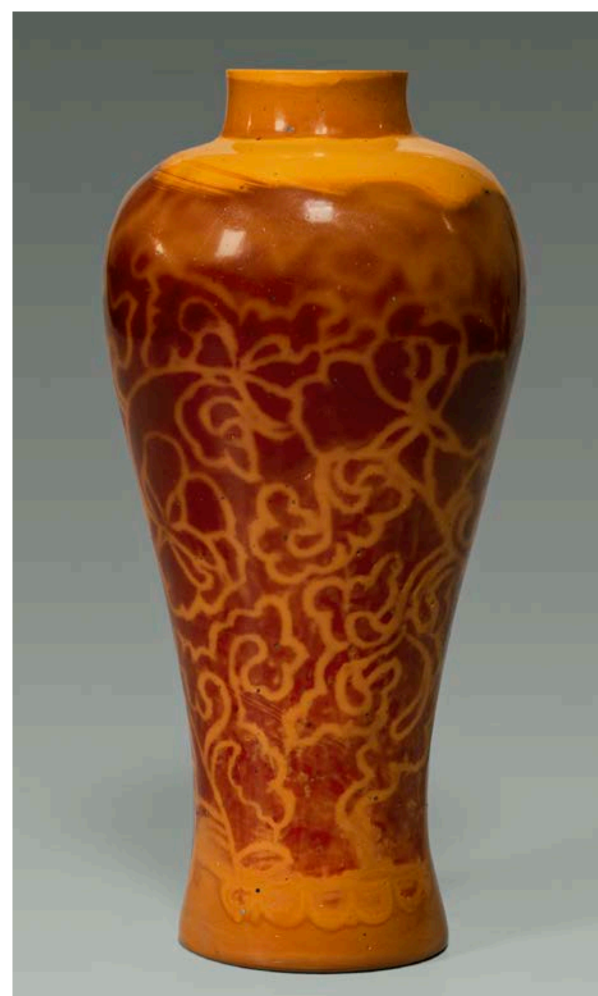

fig. 4 Vase. China, Qing dynasty (1644–1911), Qianlong period (1736–95). Glass, H. 6¾ in. (17.1 cm). Toledo Museum of Art, Gift of Edward Drummond Libbey (1920.14)

Additionally, iron, also present in the samples, could have acted as a reducing agent within the glass, together with tin, arsenic, and antimony. Recent attempts to recreate *rosichiero* glass, a transparent red glass described by seventeenth-century Italian and German glassmakers, have shown that the addition of iron oxide (Fe_2O_3) was essential to the reduction of the copper particles.[22] The researchers experimented with several recipes for this ingredient, and they found that the color of the final result was not only affected by the recipe for producing the iron oxide, but also by the order in which the glass components were mixed, as well as by complex firing conditions.[23] In light of these studies, it is possible that iron oxide lead stannate, and other arsenic- and antimony-containing compounds contributed to the orange coloration of the samples, although more investigation is required to fully understand the role of each element in the final result.

The few pieces of persimmon glass that bear pictorial patterns provide important clues as to how the mottled effects characteristic of this type of glass were achieved. For instance, a small vase in the Toledo Museum of Art shows a floral pattern in a mid-orange color against a darker, orange-red background (fig. 4). This reddish area appears divided into two sections, with seams running vertically and horizontally near the foot and neck of the piece, suggesting the use of a mold. It is possible that the lighter lines making up the floral pattern were created in relief within the mold, thus impressing an intaglio depression into the glass object. Exposed to air, these cavities (and the surrounding surface) would have turned into a lighter shade of yellow-orange. The darker areas could have been obtained by polishing down the surface of the object until flush with the depressions, thus exposing the darker orange tones of the interior of the glass and retaining the lighter yellow-orange of the pattern. It is conceivable that this technique was also used to create abstract mottling, possibly by polishing unevenly applied (or molded) glass layers briefly exposed to air. The production of persimmon glass at the Qing court workshops shows the active development of new glassworking techniques, an experimental approach to silicate pyrotechnologies that was also deployed at the enameling workshops.

ORANGE-ENAMELED PEONIES

Although present in a handful of seventeenth- and eighteenth-century enameled porcelain,[24] orange enamels from this period have not been the subject of scientific analysis to date.[25] A small porcelain bowl with painted enamel decoration of two peonies and a pink daisy (fig. 5) provided a unique opportunity to study these colors, and complement the information obtained from the persimmon glass. The two peonies feature orange petals painted in a gradient, with a darker color near the pistil that lightens to yellow near the edges of the petals, which are outlined in brown. Darker ruby-red spots between some

fig. 5 Bowl with flowers. China, Qing dynasty (1644–1911), Yongzheng period (1723–35). Porcelain painted in overglaze polychrome enamels, H. 2⅛ in. (5.4 cm). The Metropolitan Museum of Art, Alfred W. Hoyt Collection, Bequest of Rosina H. Hoppin, 1965 (65.86.12)

of the lower petals lend depth and three-dimensionality to the overall depiction of the flowers.

The palette of the overglaze enamels was studied by a combination of XRF and Raman spectroscopy,[26] with specific attention to the making of the orange peonies. Analyses indicate that the lead arsenate-opacified yellow enamels are colored with a mixture of lead-tin yellow type II and likely lead-tin-antimony triple oxide yellow colorants in different proportions.[27] Ruby red is obtained from colloidal gold,[28] the dark brown used in the contour lines from coarse hematite pigment particles,[29] the green from a copper-based colorant containing traces of zinc, and the blue from a cobalt-containing colorant.[30] The orange grading hues were obtained by using yellow and ruby-red colorants in layers, in different proportions and producing a characteristic final texture (fig. 6a, b), while the light and dark pink hues were obtained by mixing lead arsenate opacifier together with colloidal-gold ruby red in different proportions. Most of the decorations are realized by combining several pigments. For instance, traces of green and brown are often found in small amounts in yellow and ruby red enamels (fig. 6c); blue is often mixed with green to render the leaves (fig. 6d), stems, and sepals; and green is applied over yellow in the pink flower's stamen. Similarly, based on XRF analysis,[31] the amount of lead-tin yellow type II varies, and could prevail over the antimony-containing yellow in some decorations.

Tracing the origins of the new colorants that make up what is commonly known as the famille rose palette is a complex and ongoing endeavor.[32] Lending its name to these expanded possibilities in polychrome enameling, the ruby-red enamel was created by the precipitation of colloidal gold, and often opacified with lead arsenate white to create a soft, milky pink color. There is evidence that an enameler from South China introduced the technique for producing ruby-red enamels to the court in 1716, and intensive experiments to create this color were already underway at the imperial workshops before the end of the Kangxi period in 1722.[33] Although ruby-red enamels have been the subject of several scientific studies over the past forty years,[34] their mixing with colored enamels other than opaque white has been largely overlooked. A handful of studies have shown that Chinese enamelers integrated this new ruby red into a cobalt-blue enamel matrix, producing deep purples.[35] And, as noted above, ruby red was often mixed with lead-arsenate to create an opaque pink color. But to the authors' knowledge, the mixing of colloidal-gold ruby red with yellow colorants, resulting in orange-colored enamels, has not been studied to date.[36]

Yellow enamels created by compounding lead, tin, and antimony also appeared in painted enamels on porcelain in early eighteenth-century China. For instance, lead-tin-antimony triple oxide was detected in the yellow background of an imperial piece dating to the

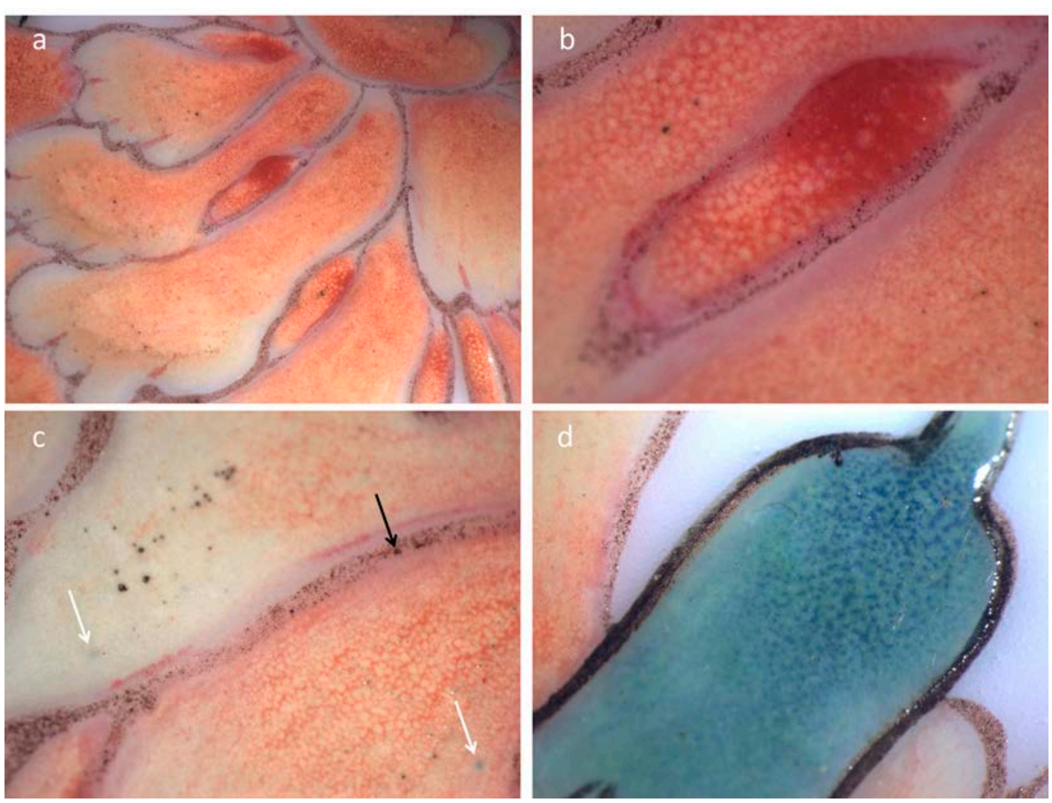

fig. 6 (a, b) Details of the orange peonies obtained by applying colloidal-gold ruby red over a yellow enamel; (c) Small traces of copper-based green (indicated by white arrows) in yellow and orange petals; the dark contours are obtained using coarse hematite particles (indicated by black arrow); (d) A mixture of green and blue enamels is used to render the gradations of the flower's receptacle.

Kangxi period, while an enameled dish fragment attributable to the Yongzheng imperial workshops contained the triple oxide in a yellow flower, and lead-tin yellow type II in its opaque yellow background.[37] Although it is tempting to attribute these new yellow colorants to the adoption of European enameling materials and techniques, it is worth noting that they were used in cloisonné enamels in China prior to European contact. A study of seventeenth-century cloisonné objects from the Ashmolean Museum, Oxford, has revealed the presence of lead-stannate as a yellow colorant.[38] In 2010, lead-tin yellow type II was detected in the yellow sections of a cloisonné pitch-pot vase dating to the turn of the sixteenth century in the Musée des Arts décoratifs, Paris.[39] The same study found lead-tin-antimony triple oxide as well as lead antimoniate in the yellow sections of cloisonné objects dating from the fifteenth to the seventeenth century.[40] Given their presence in Ming dynasty cloisonné enamels, these yellow colorants were likely available to enamelers in the subsequent Qing dynasty. During the Yongzheng period, artisans working in both cloisonné and painted enamels operated in the same physical location (the enameling workshop: *falang zuo*, 法瑯作), making it likely that they shared raw materials whenever possible, rather than rely on infrequent shipments from Europe.

The process of layering enamel colors has been documented in two studies of enameled porcelain fragments excavated at the Forbidden City, Beijing.[41] However, these studies only report the layering of colored enamels on top of an opaque arsenic-white enamel base,[42] rather than the successive layering of colors to obtain secondary hues. In the example at hand, it appears that the ruby-red enamel was applied in a light-colored wash over the opaque yellow enamel to create orange gradients and shading. In the Yongzheng period, the ruby-red and yellow enamels were recent additions to the overglaze enameling palette, and finding ways to mix them together was but one of the experimental projects of the Qing court workshops. Although more comparative research is required, it is possible that the method of layering was adapted from European watch enameling of the second half of the seventeenth century, which involved building up color by superimposing enamel layers in a manner akin to oil or tempera painting.[43] Given that European missionaries with enameling and painting abilities worked alongside Chinese artisans at the enameling workshops, it is likely that painting techniques were exchanged and developed collaboratively.

Over the first half of the eighteenth century, new approaches to silicate pyrotechnologies led to unprecedented developments in glass and enamels in China, and focusing on the color orange has provided a productive entry point into these experimental practices. The warm hues of persimmon glass were likely obtained by manipulating reducing conditions to create color variations using a single colorant; meanwhile, superimposing two newly available enamel colors created the bright orange peonies on the porcelain bowl. The reduction and oxidation sequencing needed to achieve persimmon glass, and the formation of colloidal gold needed to produce the ruby-red enamel, are both complex systems. It is perhaps not surprising that producing orange colors was different for glass and enamels, since the working processes and temperatures are quite different for forming a glass object than for decorating porcelain with multiple colors of enamel. The development of two different ways of achieving orange colors—one in glass, the other in enamels—illustrates the degree of experimentation in glass technologies at the Qing court workshops in the eighteenth century. Although colorants frequently transited between the glass factory and the enameling workshop, the archival and scientific evidence presented in this paper shows that Qing-dynasty artisans had a sophisticated understanding of the affordances of each medium. The research and fine-tuning that undoubtedly went into developing these new hues were a direct result of increased attention to glass and enamels in the Kangxi, Yongzheng, and Qianlong periods, contributing to the dramatic expansion of the color palette in Qing imperial art and material culture.

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NOTES

1 An early system found in the *Zhouli* (周禮; Rites of Zhou) added a sixth color: dark (xuan, 玄), sometimes interpreted as dark red. "Dongguan Kaogong ji," n.d., section 60.
2 Sunzi 1910, 36.
3 Bogushevskaya 2018.
4 Han 2016, 234, 297; Yu Feian 1988.
5 Siebert, Chen, and Ko 2021, 28.
6 Shih 2013.
7 Bellemare 2023.
8 Xue 2021.
9 Ibid., 99–100.
10 On the establishment of the imperial workshop archives, see Chen 2013.
11 Realgar (*xionghuang*, 雄黃) is only mentioned as a mineral. In some instances, it was used as a painting pigment, while in others, as a decorative stone for display. *QNZ* 4:372, 5:381.
12 *QNZ* 2:94.
13 *QNZ* 5:781.
14 *QNZ* 11:62, 85, 733.
15 Bushell 1904–6, 2:67, fig. 78.
16 Royal Academy of Arts 1935, 238.
17 X-ray fluorescence analysis was performed with a Bruker Artax instrument using unfiltered Rh radiation, a 1 mm collimator, and a live-time acquisition of 120 seconds. Two different conditions were used depending on the elements to detect: for the detection of low atomic number elements ($Z \leq 17$) the analysis was realized at 20 kV and 800 μA under a flush of helium. For the detection of elements with atomic number >17 the analysis was realized in air at 50 kV and 700 μA. This noninvasive analytical approach was deemed necessary because of the impossibility of collecting samples from intact glass objects.
18 This assumption is based on the scantiness of elements associated to other components, such as potassium, calcium, and lead, and by comparison with published comparable glass. See Xue and Maxwell 2022, 144–45.
19 See, for instance, sample CH7 in Ma et al. 2020, 29–30, and samples 19 and 20 in Xue and Maxwell 2022, 148–49.
20 The thorough characterization of the copper-containing phases would require the combination of analytical techniques such as Raman spectroscopy, UV-visible absorption spectroscopy, micro-X-ray diffraction, and transmission electron microscopy, possibly on a small sample of glass. See, for instance, Brill and Cahill 1988, 17; Freestone and Barber 1992; Colomban 2009; and Sciau, Noé, and Colomban 2016.
21 Brill and Cahill 1988, 19–23. Lead is thought to keep the cuprous copper from becoming oxidized, while tin might have been derived from the use of bronze rather than pure copper in the glass melt. A Roman glass fragment with orange bands also contained copper and lead; see Basso et al. 2014, 244–45 and sample H3.
22 Hagendijk, Vilarigues, and Dupré 2020, 331.
23 Ibid., 337.
24 See, for instance, a covered box with "hundred boys" motif dating to 1650–70 from the Ashmolean Museum, Oxford (inv. EA1978.1067).
25 Dana Norris (2021, 229–31) has analyzed orange-colored enamels on objects dating from the nineteenth to twenty-first century, finding that most of them were created by iron oxide, sometimes mixed with yellow colorants such as antimony or tin.
26 X-ray fluorescence analysis was performed with a Bruker Artax instrument using unfiltered Rh radiation at 50 kV, 700 μA, a 0.6 mm collimator, and a live-time acquisition of 120 seconds. Raman spectra were acquired with a Bruker Senterra Raman microscope using a 785 nm laser line with integration times of 15 seconds and three co-additions. The Raman measurements were obtained using a ×50 objective. Powers at the sample were set between 1 and 10 mW using neutral density filters.
27 Lead-tin yellow type II was identified by Raman spectroscopy (Raman bands at 139 cm^{-1} and 326 cm^{-1}), while the presence of lead-tin-antimony triple oxides is suggested from the detection of antimony by XRF analysis of the yellow decorations. Although Raman spectroscopy did not find any trace of lead antimonate, it is not possible to exclude its presence in the yellow enamels based on the available data.
28 Identified by the presence of characteristic X-ray Lα-lines of gold of small intensity.
29 Hematite was positively identified by the Raman bands at 227, 245, 293, 411, 494, 610 cm^{-1}, and by the dominant Kα-lines of iron in the XRF spectra.
30 The cobalt-containing colorant is characterized by the presence of potassium; nickel; traces of copper, zinc, and manganese; and by the absence of detectable bismuth, suggesting a possible Western provenance of the raw materials. See Colomban, Kırmızı, and Simsek Franci 2021.
31 The relative proportions of these two colorants were derived from the ratios of the intensities of tin and antimony Kα-lines in yellow decorations.
32 For a summary of recently published scientific analyses of pink, blue, yellow, and white enamels, see Bellemare 2022.
33 Ibid., 150; Yu Pei-chin 2020.
34 See Zhang 1980; Mills and Kerr 1999; Wang 2013; and Norris et al. 2020.
35 Kingery and Vandiver 1985, 378–79. Dana Norris, Dennis Braekmans, Kelly Domoney, and Andrew Shortland (Norris et al. 2020, 508) found that purple enamels on metal and porcelain plates were produced either by manganese and iron or by mixing cobalt and gold, but these could not be detected with the methods used.
36 Gold-based orange enamels were detected on later eighteenth- and nineteenth-century nonimperial porcelain, but the authors do not indicate whether the ruby red was mixed with yellow colorants. Colomban et al. 2020a, 930.
37 Miao, Yang, and Mu 2010, 149–50.
38 Henderson, Tregear, and Wood 1989, 142–44.
39 Kırmızı, Colomban, and Quette 2010, 787–88.
40 Ibid.
41 Li et al. 2018; Duan et al. 2019.
42 It is possible that this method was adopted from enameling on copper alloys, where applying an opaque white base coat over the metal was necessary for the colors to pop.
43 This technique differed from most European glass and metal enameling, and was later replaced by a "pointillistic" method of mixing colors and creating gradients. Colomban et al. 2020b, 10–11.

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ABBREVIATION

QNZ Zhongguo di yi lishi dang'an guan, Xianggang zhongwen daxue wenwu guan 中國第一歷史檔案館. 香港中文大學文物館 [China First Historical Archives, Chinese University of Hong Kong Art Museum]. *Qinggong neiwufu zaobanchu dang'an zonghui* 清宮內務府造辦處檔案總匯 [Collected archives of the workshops of the Qing Imperial Household Department]. 55 vols. Beijing: Renmin chubanshe, 2005.

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