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# A Chinese bronze *gui* vessel: genuine Western Zhou object or fake?

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**Summary** The authenticity of a Chinese bronze food vessel or *gui* purchased in the 1930s by the British Museum and attributed to the Western Zhou period was called into question because of its unusual dark green patina. An initial investigation of the core material from the handles by thermoluminescence dating in the 1970s indicated that although it was unlikely to have been cast in the Western Zhou period, its manufacture was not recent. The defective shape of the vessel's rim, severe casting flaws, uncharacteristic decorative details and the unusual core material in the handles were noted and prompted a reinvestigation.

The vessel was examined using microscopy, X-radiography, X-ray fluorescence analysis, scanning electron microscopy coupled with energy dispersive X-ray spectrometry, X-ray diffraction and Raman spectroscopy. Although the composition of the alloy is acceptable for an ancient Chinese bronze, the uncharacteristic casting features, the presence of an artificial patina and the unusual composition of the core material suggest that the vessel is unlikely to be a genuine Western Zhou piece. It is possibly an ancient copy produced between the twelfth and the fourteenth century (Song–Yuan dynasties), when there was a revival in interest in older traditions and objects.

## INTRODUCTION

A Chinese bronze food vessel, or *gui* (1936,1118.65), was purchased by the British Museum from George Eumorfopoulos (1863–1939) in the 1930s. This vessel with two handles is decorated with four *taotie* masks in the main band and with two bands of spiral motifs around its neck and foot, Figures 1 and 2. There is an animal head at the centre of the upper band on each side, Figure 1. The vessel bears an inscription consisting of four characters on the bottom, which reads 'grandfather *Gui* (and) father *Ding*' (祖癸父丁). This text was recorded in the list of Shang and Zhou Dynasty bronze inscriptions, the *Yin zhou jinwen jicheng* (殷周金文集成登录: 03296), and on that occasion was dated to the earlier Western Zhou period. Perceval Yetts' study of the vessel in his 1929 catalogue of parts of the Eumorfopoulos collection remains inconclusive as to its date but attributes it to either Shang or early Western Zhou based on its inscription [1]. This vessel shares similarities with both Shang and early Western Zhou vessels, but differentiation between these periods is complicated by the continuation of Shang conventions, such as inscribing the titles of ancestors onto bronzes, and Shang styles of writing and decoration, such as the *taotie*, into the early Western

Zhou period. A *gui* vessel found in a Western Zhou tomb in Hejiacun, Qishan, Shaanxi in 1966 has a similar profile to the Eumorfopoulos *gui* [2], and a rapid visual comparison of the two suggests that the latter vessel originates from the early Western Zhou period.

The vessel from the British Museum has a rim that is not perfectly level, in common with most ancient castings, and it appears to be heavily coated over its entire surface. This dark olive-green surface does not resemble that of a normal corroded Chinese bronze and this discrepancy led to an examination of the vessel in the British Museum laboratory by Oddy and Tite in the 1970s to establish its authenticity [3]. Their report concluded that the alloy composition was acceptable for an ancient Chinese bronze, but that although thermoluminescence dating of the core from the handles suggested that it was unlikely to be a modern casting, it was not possible to confirm that this was a Western Zhou vessel [3]. However, the casting technique of the object was not studied and the defective shape of the rim, the unusual appearance of the handles (with dark core material and very thick mould join marks) and the decoration lines on the neck and the foot, which are not as smooth as on most ancient Chinese bronzes, prompted a recent re-examination.



FIGURE 1. Chinese bronze *gui* vessel (1936,1118.65) showing the three bands of decoration with the animal heads in the upper band and the repairs to the foot



FIGURE 2. Chinese bronze *gui* vessel (1936,1118.65) showing handle 1

### SCIENTIFIC EXAMINATION

For this reassessment the vessel was examined using microscopy, X-radiography, X-ray fluorescence analysis (XRF), scanning electron microscopy coupled with energy dispersive X-ray spectrometry (SEM-EDX), X-ray diffraction (XRD), and Raman spectroscopy.

The metal composition was studied by XRF using an Artax  $\mu$ XRF spectrometer with a molybdenum target X-ray tube rated up to 40 W and operated at 50 kV and 800  $\mu$ A with a counting time of 200 seconds. The analysis

was carried out on small areas in inconspicuous places that were cleaned by abrasion using a scalpel and silicon carbide paper.

A small sample of the core material from a handle was analysed by SEM-EDX using a Hitachi S-3700N variable pressure SEM with an Oxford INCA Energy system. The analyses were run at an accelerating voltage of 20 kV at low vacuum (50 Pa) with a working distance of 10 mm.

Ultraviolet-induced fluorescence imaging and Fourier transform infrared (FTIR) spectroscopy were used to



FIGURE 3. X-radiograph of the vessel showing repairs on the foot (indicated by an arrow) and the dark spots in the region of the rim that indicate porosity in the casting



FIGURE 4. The interior of the vessel showing the inscription on the bottom and a faint rectangular mark around it

investigate the surface of the vessel in areas that were thought to be restored. The surface patina was identified by XRD, using a Philips PW1012/90 Debye-Scherrer camera with Cu K $\alpha$  radiation, and by Raman spectroscopy using a Jobin Yvon Infinity spectrometer with a green laser (532 nm) that produces a maximum power of 1.2 mW at the sample.

#### EXAMINATION RESULTS

The vessel weighs 3060 g and is approximately 157 mm high and 295 mm wide (including the handles). The diameters of the rim and foot ring are approximately 218 and 168 mm respectively. The wall of the vessel is 2–2.6 mm thick and the foot ring is 1–2 mm thick. The thickest part of the rim is about 8 mm.

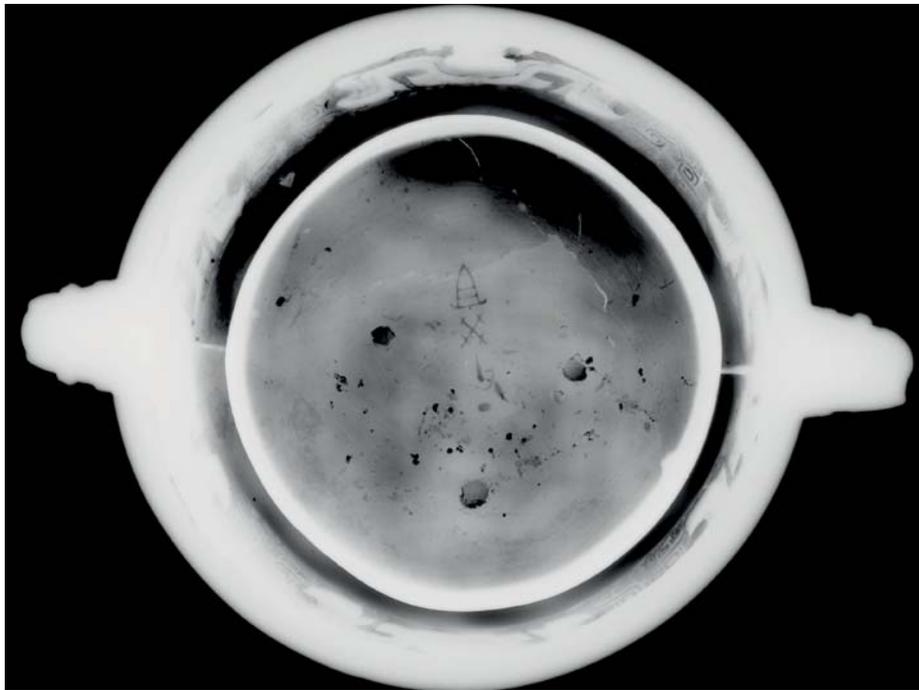


FIGURE 5. X-radiograph of the bottom of the vessel showing the three chaplets and the inscription



FIGURE 6. The underside of the bottom of the vessel showing three recessed chaplets (indicated by arrows) and irregular thickenings (indicated by ellipses)

A number of holes are present in the foot ring and in the handles, Figures 1 and 2. The foot ring is cracked (Figure 1), where repairs were revealed by X-radiography, Figure 3. X-radiography also showed a large number of gas bubbles at the rim, indicating that the vessel was probably cast upright.

There is a faint rectangular mark around the inscription (Figure 4), which suggested it might have been made separately. However, this mark does not feature in the X-radiograph (Figure 5), disproving the theory that there was a join

in the metal. Three rounded chaplets that show clearly in the X-radiograph cannot be seen on the interior of the vessel (Figure 4), as they are recessed below the surface level, but they are visible on the rounded underside of the vessel, Figure 6. Although some chaplets have been reported to be thinner than the full depth of the casting [4], it is difficult to understand why all three of these chaplets are recessed as this would have caused them to fail in their function, which would have been to maintain a proper separation between the core of the



FIGURE 7. The handles showing the thick mould join marks (indicated by arrows): (a) handle 1; and (b) handle 2

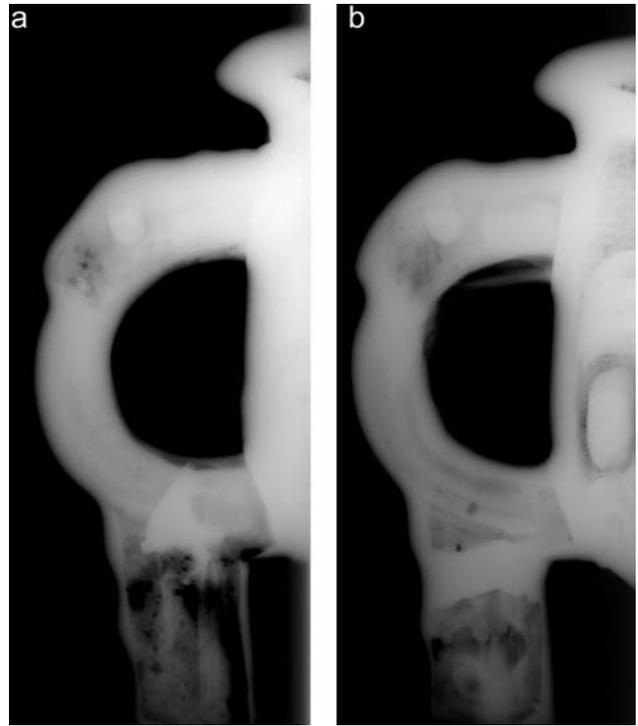


FIGURE 8. X-radiographs of the handles showing a greater density of metal at the junction of the handle lugs: (a) handle 1; and (b) handle 2

upper body and the core of the foot. Three irregular triangular thickenings at the junction of the bottom and foot, seen in Figure 6, were probably designed to strengthen the vessel wall and also to counteract 'hot cracking' at the sharp angle where bottom and foot meet [4].

Mould join marks are visible on the underside of the vessel wall in line with the animal heads at the neck and below the handles, Figure 7. The marks are so thick that some of them are flattened, Figure 7b. Severe casting flaws are visible on handle 2 with metal missing on the bottom of the handle lug. Clay core material is still present in the handles, although it is difficult to see through accumulated dirt. X-radiography revealed that the handles were probably cast with the body of the vessel, as there is no sign of any other means of connection between the body and handles, Figure 8. A piece of denser metal was revealed by X-radiography in the lower part of each handle, Figures 8a and 8b. They may have been secondary castings to repair flaws in the original casting of the handle lug, but analyses could not be carried out to confirm this because of the heavily patinated surface.

XRF analysis was carried out on the foot ring, the bottom of each handle lug and a residual mould join under the rim; the results are listed in Table 1. Because the analysis is of the surface and since minimal preparation was carried out to remove possible surface enrichment and patina, etc., the results may not accurately represent the composition of the body of the object. Nevertheless, little difference in composition between different parts of the vessel was detected, suggesting that it was a single cast, and confirming the observations made by X-radiography. A drilled sample

TABLE 1. XRF results of surface analysis for *gui* vessel 1936,1118.65

Area analysed	Cu	Pb	Sn	Fe	As
Foot ring	78.7	6.1	14.4	0.1	0.4
Mould join under rim	74.0	6.6	18.4	0.1	0.5
Handle lug 1	74.7	8.1	16.2	0.1	0.6
Handle lug 2	76.4	7.2	15.7	0.1	0.5
Repair on foot ring <sup>a</sup>	3.2	71.7	24.2	0.5	–

Notes

All the results are presented as weight percentages of the elements.

<sup>a</sup> Zinc was detected in this region as a minor element.

TABLE 2. Atomic absorption spectrometry results for the foot ring of vessel 1936,1118.65 [3]

Cu	Pb	Sn	Ag	Fe	Sb	Ni	Co	As	Bi	Zn	Total
76.8	6.8	13.5	0.066	0.073	0.04	0.027	0.003	0.39	0.026	0.007	97.72

Note

The results are presented as weight percentages of the elements.

from the foot ring was analysed by atomic absorption spectrometry in the 1970s and produced a result (Table 2 [3]) consistent with that from XRF. The XRF analyses also identified the solder repair on the foot ring as a soft solder of tin and lead, Table 1.

The vessel appears to be heavily coated across its entire surface. A small patch of patina under the rim was revealed as a retouching under ultraviolet light and by solubility tests using organic solvents. The green patina on the rest of the surface seems to be confined to areas of relief and although it was identified by XRD as malachite, a common corrosion product of copper, the bright particles in the patina resemble the ground mineral rather than a naturally formed corrosion product, Figure 9. The red/brown particulate material seen

on exposed areas on the foot ring was identified as hematite by Raman spectroscopy, Figure 10. Ochre, which contains mainly hematite, was probably used to produce the appearance of cuprite, a red corrosion product of copper usually found next to the metal on a corroded bronze. The restoration on the foot and the application of this false patina predate the object’s arrival at the British Museum.

The surface coatings across the vessel were analysed using FTIR spectroscopy. The coating on the body was found to be a carbohydrate, probably gum arabic, which may have been used as a varnish or a binder for an applied patina. The coating on the foot ring seems to be shellac, mixed with another, unidentified substance that could be a contaminant. Shellac was used widely in conjunction

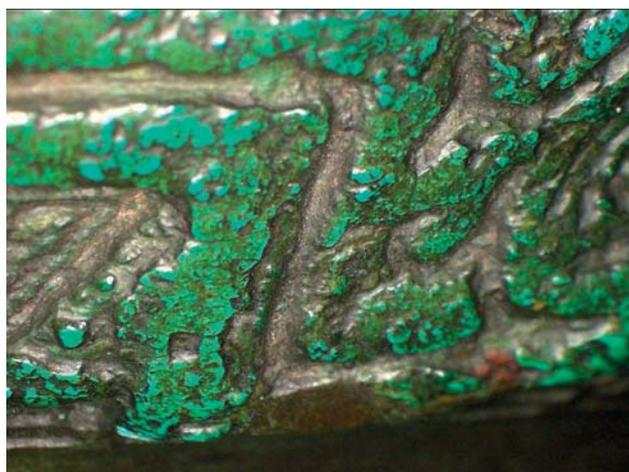


FIGURE 9. Detail of the green patina on the surface of the vessel. Image width: 13.5mm



FIGURE 10. Detail of the red/brown patina on the foot ring, which was identified as hematite by Raman spectroscopy. Image width: 13.5mm

TABLE 3. SEM-EDX results for core materials from Western Zhou vessels

Object	Collection	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	FeO	Corrosion products
1936,1118.65	British Museum	1.2	2.2	13.9	58.4	5.2	2.8	4.0	0.6	6.7	Cu, S
1973,0726.11	British Museum	1.9	2.8	14.4	51.1	nd	3.3	7.7	0.9	10.6	Cu, S
WZHV/black [17]	Fufeng, Shaanxi	2.4	1.5	11.4	68.4	nd	4.3	7.0	0.7	4.4	
WZHV/grey [17]	Fufeng, Shaanxi	1.7	1.8	10.8	72.5	nd	3.1	5.6	0.4	4.1	

## Notes

The results are presented as normalized weight percentages of the oxides of the elements. 'nd' indicates not detected, that is below the detection limit of 0.5%.

with dry powder pigments as a retouching medium [5], and it is very common in repairs and false patinas on old Chinese bronzes [6]. As mentioned above, the foot ring has clearly been repaired and shellac was probably used as the binder in the application of red/brown pigment seen in Figure 10.

## DISCUSSION

Although the composition of the alloy is consistent with Zhou bronzes, the authenticity of this vessel was suspect because of its unusual dark olive-green surface, the defective shape of the rim and severe casting flaws in the handles. However, the dark green surface does not necessarily point to a fake, as a *gui* vessel of the Shang period in the Sackler collection of the Smithsonian Institution (S1987.51) has a strikingly similar colour, but a perfect shape and decoration. Thermoluminescence dating of the core from one of the handles on the British Museum *gui* vessel (1936,1118.65) produced an estimate of 440 rads, while objects that are 3000 years old should have an archaeological dose of more than 900 rads, assuming a dose rate of at least 0.3 rads per year and no anomalous fading [3]. The core material from the handles of the vessel from the Sackler collection, S1987.51, was shown by thermoluminescence to have been fired in antiquity [7], but unfortunately the record of its thermoluminescence dose is not available for comparison with that of the vessel studied here. Lead isotope analysis has sometimes proved helpful for determining provenance [8], but the technique was not available to the authors.

The thermoluminescence dating of the clay core suggests the vessel is unlikely to have been cast in modern times [3], but it could be that it is a copy of a Bronze Age vessel made during a later period, for example in the Song dynasty. The production of bronze in China did not end with the Chinese Bronze Age and vessels continued to be made for tombs, temple altars and to serve in the home as wash basins, incense burners and vases [9]. From the Song period it became popular to collect antiquities, which served as a link to the past during a period of revival of Confucian thought [10, 11]. In particular, inscribed bronze vessels from the

venerated Zhou period were collected as historical documents and as "links to men of the past" [12]. Reproductions of ancient vessels were made at and outside the Song court to reinstate the proper ancestral offering ceremonies that were pieced together from ancient texts. Those few vessels that survive from the court of Emperor Huizong (reigned AD 1100–1125) are convincing reproductions of their Shang and Zhou counterparts and have successfully fooled scholars for centuries [12]. An emergent market for antiquities helped to satisfy collectors in the Song period [12], and this *gui* vessel, which emulates an authentic Western Zhou vessel with great accuracy, may be seen in this light. It could be either a reproduction made to meet the demand for genuine ancient vessels or a straightforward attempt to provide a vessel for use in the revived offerings to ancestors. Although collectors in the Song period were aware of the original function of *gui* vessels for making food offerings, they re-employed the vessels as incense burners [11].

Blowholes are present on the foot ring as well as on the handles of this vessel, Figure 2. It has been reported that blowholes are often present on bronzes produced in sand moulds or by the lost-wax method, but they have rarely been seen on genuine Chinese bronzes of the Shang and Zhou dynasties [13]. Sand casting was probably introduced in China for coin production in the Sui and Tang dynasties (AD 589–906) [14], while the lost-wax method has been used in China since the Han dynasty (206 BC–AD 220), if not earlier [15]. Both the sand casting and lost-wax methods could, therefore, have been used in the Song dynasty and bronzes of the Song period cast in piece-moulds have been found in the Pengzhou hoard from Sichuan province [16].

The inner surface of the vessel appeared to be blackened and 'dirt' wiped from the surface was identified by Raman spectroscopy as amorphous carbon. This suggests that the vessel could have been used for incense, although such an interpretation is inconclusive.

The surface of the cores within the handles is also black, but beneath this layer the core material appears to be yellow/brown and has a more sandy texture than the clay normally found in the cores of early Chinese bronzes. SEM-EDX analysis of the core material showed a significant amount of phosphorus (5.2% P<sub>2</sub>O<sub>5</sub>), which differs from the normal composition of clay cores, Table 3. The core material was

found by XRD analysis to contain quartz (SiO<sub>2</sub>, the main component of sand) and sodium hydrogen phosphate hydrate (Na<sub>2</sub>HPO<sub>4</sub>·2H<sub>2</sub>O). To the authors' knowledge, phosphorus has not been found at levels in excess of 1% in any cores from early Chinese bronzes [17–20]. The presence of phosphorus could be due to the addition of organic materials to the core material to make it more permeable and so improve the quality of the cast. Plant ash was reportedly found in the fabric of the moulds from the Houma foundry [20], which dates to the Eastern Zhou period. Other sources of phosphorus could be contamination in the burial environment from bones or agricultural fertilizers. Additional data on core compositions from other objects in the British Museum and other collections would help to interpret these results more fully.

The mould joins on this object are unusually thick, the three chaplets at the bottom of the vessel are recessed (which might indicate that they are imitation rather than functional) and the three 'triangular' thickenings at the junction of the bottom and foot are irregular. All these features would be unusual for a genuine Western Zhou vessel, but they might be explained if the vessel was perhaps cast in the Song and Yuan dynasties when copies of early bronzes were popular. This hypothesis, however, is difficult to prove, as casting techniques and the alloys used for Song 'reproductions' have not been studied in sufficient depth.

## CONCLUSIONS

Although the composition of the alloy is acceptable for an ancient Chinese bronze, the thermoluminescence dating of the core from the handles does not support a date in the early Western Zhou period; but neither does it indicate that the vessel was cast in modern times. The unusual casting features, the presence of an artificial patina and the unusual composition of the core material suggest that the vessel is unlikely to be a genuine Western Zhou object and is possibly an ancient copy produced in the twelfth to fourteenth centuries, in the Song to Yuan dynasties.

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