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New light on old swords from Iran

St John Simpson and Susan La Niece

Summary Iran is very rich in metal ores and has had an unbroken tradition of metalworking for at least 7000 years. At the end of the second millennium BC a number of regional cultures emerged within Iran, particularly in the north western and western parts of the country and these were particularly proficient in metalworking. Apart from a small number of stray accidental finds, the first occasion on which a significant number of such pieces entered Western collections – including the British Museum – was during the late 1920s. Almost all of these were acquired via the art market and lacked secure excavated provenances. This paper looks at two types of sword that have been scientifically examined with X-radiography, X-ray diffraction and X-ray fluorescence analysis. The results indicate that some swords with bronze hilts were certainly cast-on to bronze blades, but although some excavated examples show the casting of bronze hilts onto iron blades, many others circulating on the art market show unmistakable signs of having the corroded iron blades replaced by bronze blades from separate weapons of the same typological class. The results call into question some previous assumptions in the literature about swords of these types and underline the importance of using scientific techniques when analysing pieces purchased from the art market.

INTRODUCTION

The existence of a highly developed metalworking tradition in parts of north west and western Iran during the late second and early first millennia BC is well known following chance discoveries and archaeological investigations in the Talish, Dailaman and Luristan regions over the course of the past century, Figure 1. Many of the artefacts produced belong to regionally and temporally distinct types and their basic typological classification and development is now understood [1, 2].

In recent years there have been a growing number of scientific analyses of both iron and copper alloy objects from Luristan, including pieces excavated by the Belgian Archaeological Mission to Iran [3–6]. Moreover, there have been detailed examinations of multi-component iron swords from the same region [7–9], and a small number of analyses of unprovenanced pieces in public and private collections [10, 11, 12; pp. 325–341]. Less research has been carried out on objects deriving from north west Iran [13–16], but a small number of Iron Age Iranian swords in Japanese collections have recently been analysed in detail [17–20]. The conclusion drawn in the most recent of these studies was that swords that were described as "bronze swords with an iron core" were made for ritual reasons and it was suggested that if such a sword was encountered, it should be X-radiographed so that "more can be revealed" [19; p. 406].

This contribution looks at swords of two types: those with 'cotton-reel' pommels and those with split 'ear' pommels. A sword of the cotton-reel type and another of the split ear type from the British Museum collections were examined, as were four split 'ear' type swords and a hilt from a private collection.

ANALYTICAL TECHNIQUES

The analytical techniques used in this research were as follows. A stereomicroscope was used for the surface investigation and X-radiography was undertaken using a Siefert DS1 X-ray tube. Exposure conditions were 90 kV for 60 mA minutes. The images were recorded on Agfa D7 radiographic film and scanned digitally at a resolution of 50 μm. The scanned images were processed in *Adobe Photoshop* to enhance the images to a publication standard, but without adding or subtracting any features seen on the films. X-ray diffraction (XRD) analysis on small samples of the patina was carried out using Debye Scherrer cameras. The metal was analysed by X-ray fluorescence (XRF) using an Artax μXRF spectrometer with a molybdenum target X-ray tube rated up to 40 W and operated at 50 kV and 800 μA with a counting time of 200 seconds. All the XRF analyses, except those in Table 1, were carried out on the uncleaned surface of the metal so the results are treated qualitatively with the

FIGURE 1. Map of regions and sites in north west Iran mentioned in the paper

TABLE 1. XRF analyses on drilled samples from sword 1904,1202.1 (ME 124630)

Part	Content (weight %)								
	Cu	Zn	Pb	Sn	Ni	As	Fe	Sb	Ag
Tang	92	<0.15	0.6	5	0.1	2.1	0.2	0.3	<0.02
Blade	93	<0.15	0.3	5	0.1	1.9	0.1	0.1	<0.02

Note. The precision of the analyses is ±1% absolute for copper and ±25% relative for the trace elements; the accuracy is similar.

main and trace elements identified but not quantified. This method is non-destructive and proved adequate to identify those components that are not consistent with the original artefacts. In the case of sword 1904,1202.1 (ME 124630), however, drillings of clean metal were taken from the top of the blade and from the tang protruding from the hilt and their compositions were compared with those of drilled reference standards of known alloy composition in order to obtain a fully quantitative analysis of the metal, Table 1.

SWORDS WITH ‘COTTON-REEL’ POMMELS

Swords of this type are dated between the tenth and the eighth century BC on the basis of the association of pieces excavated in Dailaman and Talish with independently dated fibulae and other types of swords [1; p. 79, 21]. A heavily corroded iron sword with bronze hilt and pommel was found by the Japanese expedition on the surface at the looted site of Ghalekuti I in Dailaman [22; Japanese section, p. 54; Figure 8], and others found at Chagoula-Derre in Talish likewise had iron blades with bronze pommels and guards [23; Figures 468 and 481]. Two swords of the same type are reported from tombs 14 and 34 at Tomadjan, one wholly bronze and the other entirely iron [24; pp. 41 and 44–46; Figures 34, 36 and 43]. In addition, a number of other wholly bronze examples are known from the art market [12; p. 310; No. 392].

There is one example of this sword type in the British Museum collection. It was purchased in 1968 on the London art market from Mr A. Nazar and registered as 1968,1012.20 (ME 135054). It is 61.5 cm long with a maximum width of 8.2 cm. It has a broad double-edged tapering copper alloy blade with ‘blood channels’ and a cylindrical hilt ending in a large reel-shaped pommel, Figure 2. X-radiography indicates that the hilt is made up of several components, Figure 3. The blade is attached to the hilt with a white metal, identified by XRF as an alloy of zinc and tin with some copper and lead. This alloy is soft and has a relatively low melting temperature, in the range 230–420°C. The white metal has been shaped and then coated, to give it the appearance of corroded bronze, with a green-tinted paste identified by XRD as being based on barium sulphate.

The lower part of the hilt is a slightly tapering hollow tube of bronze that was once pierced, just above the centre, by a pin or rivet, but which now serves no useful purpose. The tube has been heavily filed and patinated to blend in with the artificial junction between it and the blade. A reel-shaped bronze hilt with the remains of its original iron tang has been soldered onto the top of this pastiche using a soft (low melting temperature) solder.

The patina on the blade and hilt has been identified by XRD as malachite ($CuCO_3{\cdot}Cu(OH)_2$) and cuprite (Cu_2O). The underlying alloy was identified, by qualitative XRF analysis of the uncleaned surface, as bronze (an alloy of copper and tin) with trace impurities of lead, arsenic and nickel, but no zinc.

Both the patina and metal composition of the components are compatible with ancient manufacture and burial for many centuries, but the X-radiographic image indicates some peculiarities in the structure of the hilt, which cannot be consistent with a working weapon. It is concluded that although the components are ancient, they did not originally belong together and, moreover, that the original blade that belonged to the upper part of the hilt was of iron, not bronze.

FIGURE 2. Sword with ‘cotton-reel’ pommel: British Museum 1968,1012.20 (ME 135054)

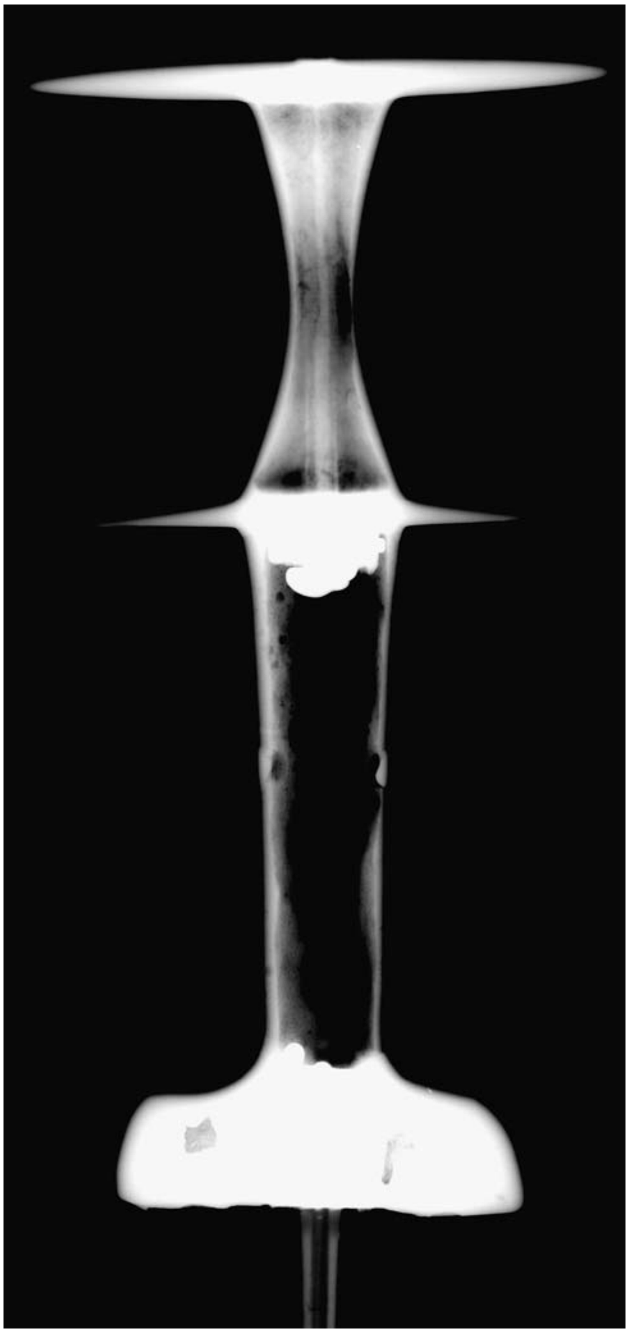

FIGURE 3. X-radiograph of the composite hilt of the sword in Figure 2. An iron tang can be seen running through the upper portion of the bronze hilt, but it does not appear in the lower, hollow section of hilt. The globular white material in the centre section and at the join of lower hilt and blade is a soft solder. The lower, tubular portion of hilt is hollow and pierced with a pin about halfway up

These results suggest that swords of this type that have been acquired through the art market should be reassessed. In the case of two bronze-bladed swords with bronze hilts, which had been acquired by the Ashmolean Museum in 1965 [1; pp. 78–79; Figure 15; Plate 7; Nos 58–59], Moorey commented that "the use of iron as a core for the hilt" was their "most remarkable technical feature", but neither has been examined scientifically [25]. A third example in the same collection has a bronze hilt attached to a heavily corroded iron blade [1; pp. 78–79; No. 60]. An almost identical sword purchased by the Metropolitan Museum of Art in 1960 shares the same features and although it was noted by Muscarella that "the pommel was certainly made and added separately; the other disk probably was too" [11; p. 100; No. 166], the possibility that these changes may have been carried out in recent times was not addressed. An additional sword in another collection was found to have an arsenical bronze blade joined by lead-tin solder to a tin bronze hilt containing a square iron rod [26], and the same applies to a sword of this type in the Okayama Orient Museum [17–19]. Moreover, it might be added that several of the published examples either exhibit suspiciously different patterns of corrosion on the blade and hilt or the pommel is slightly askew, suggesting that the tang of the blade does not continue into the hilt, as it should for a working weapon [12; p. 310; No. 392, 19; p. 413; Figure 11]. It is noteworthy that these swords are reported to have features in common with those seen on the British Museum sword, in particular soft solder between the hilt and blade, and an iron core inside the bronze hilt.

Similar results were noted following X-radiographic examination of a sword of a different type acquired via the Iranian art market by the Penn Museum in Philadelphia [10].

SWORDS WITH SPLIT 'EAR' POMMELS

This type of sword probably dates from the tenth to the ninth century BC and a number of bimetallic finds, with bronze hilts cast-on to iron blades, have been excavated at cemetery sites in the Lenkoran region of southern Azerbaijan, in the Talish and Dailaman regions of north west Iran, as well as at Geoy Tepe and Hasanlu on the western side of Lake Urmia [1; pp. 80–82, 9; p. 26; Figures 23 and 469]. In addition, an underwater find of a sword with a bronze hilt and blade was made in the Azeri portion of the Caspian Sea [27; Figure 22]. Many identical pieces with bronze or iron blades are also known from the art market, but these are usually simply attributed to 'Amlash' or north west Iran [1; p. 82, 12; pp. 314–315; Nos 397b–i, 20; pp. 26–27; Nos 31, 33 and 41–42, 28; pp. 58–59; No. 28, 29; p. 40; No. 56].

Split 'ear' pommel sword 1904,1202.1

There is one example of this sword type in the British Museum collection, purchased from one Mr Hakoumoff in 1904 as part of a small collection, which was reportedly acquired in Ardabil, and registered as 1904,1202.1 (ME 124630). It has been illustrated or cited on several occasions [8; p. 171, 30; p. 161; Plates XXXIV.1–2], but the present study offered a good opportunity temporarily to remove the sword from public display and re-examine it in detail.

The sword measures 75.3 cm in length and has three components: the blade, hilt and pommel, Figure 4. The pommel is brazed onto the hilt and has a patina of unnatural appearance. There is a repaired break in the blade approximately 45 cm from the present (damaged) tip. The metal has

FIGURE 4. Sword with split 'ear' pommel: British Museum 1904,1202.1 (ME 124630)

an etched and pitted surface with a few genuine corrosion products: minute traces of green corrosion on the edge of the blade were identified by XRD as malachite, $CuCO_3{\cdot}Cu(OH)_2$, which suggests it once had a more extensive patina formed during burial over a long period. The dark patina on the hilt, on the other hand, is easily removed with a swab moistened with acetone and appears to have been applied with a brush, so is clearly not a natural patina. All of this indicates that the sword has at some stage been chemically stripped of its natural patina and repatinated artificially.

Surface XRF analysis of the hilt and pommel identified the metal as bronze with a few percent of lead and trace impurities of silver, arsenic and nickel. The tip of a tang can be seen inside the pommel, but it is not accessible for surface analysis, so a drilled sample was taken from it and from the broken tip of the blade. The results of the XRF analyses in Table 1 show the close similarity in major and trace element composition between the two ends of the nearly 73 cm remaining length of the metal blade with its tang; small variations in lead, arsenic and antimony content are not unusual in different parts of the same casting. X-radiography of the hilt does not show any features that might indicate that the hilt is hollow (Figure 5), and is fully consistent with the hilt having been cast-on to the blade, leaving the tip of the bronze tang protruding from the top. The pommel was then brazed onto the top of the hilt.

Although this sword has clearly undergone extensive 'restoration' in the past, and little of the original patina survives, the metal composition, construction method and integrity of the blade and hilt indicate that it is a genuine piece.

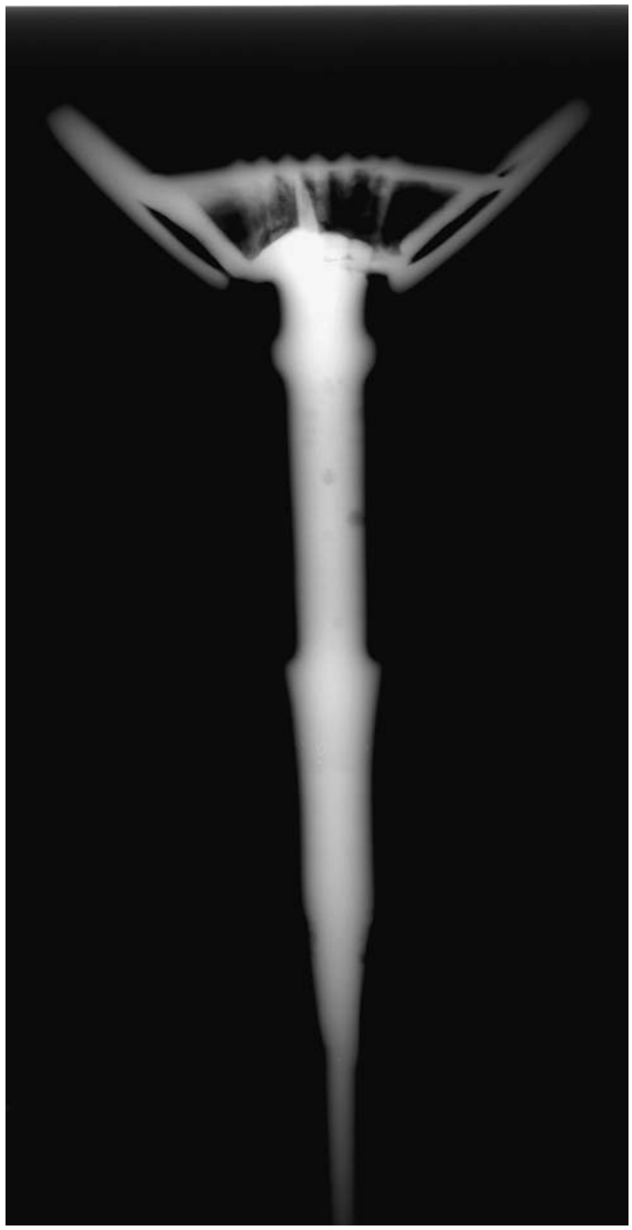

FIGURE 5. X-radiograph of the hilt of the sword in Figure 4. No discontinuities are visible either between the blade and hilt or within the hilt. The end of the tang can be seen protruding from the top of the hilt into the hollow pommel

Three additional swords and a hilt

In 1994 a second group, consisting of three swords and a single hilt fragment, belonging to the same typological class as sword 1904,1202.1 (above) were examined within the Department of Scientific Research for the purpose of authentication, Figure 6.

All the components – blades and hilts – were analysed qualitatively by XRF of the uncleaned surfaces and found to be bronzes with trace levels of lead, silver and arsenic, and in some cases also antimony and nickel. The unexpected feature of all but one of the hilts is that the tip of an iron pin or tang protruded from the top. The response to a magnet confirms that the iron continues inside the bronze hand-grip to the bottom of each hilt. Furthermore, the hilt fragment has the cut end of an iron blade protruding from it.

Every sword showed unusual fluorescence under ultraviolet radiation, particularly at the junction of hilt and blade. It transpired that the reason for this was that the grey-green 'patina' at this junction was artificial, but XRD indicated that all the swords had an apparently natural patina elsewhere on their surfaces. X-radiography showed a discon-

FIGURE 6. Sword with split 'ear' pommel from a private collection

tinuity between the blade and upper part of the tang; the blades butt onto the end of the hilts and are held in place by a soft solder of tin and lead, Figure 7. They would have had no mechanical strength on impact and so could never have functioned as weapons.

It appears clear from this study that these three swords are pastiches, but that the hilts and blades are probably ancient. The evidence of the tangs inside the hilts indicates that the original blades were of iron, with the latter having presumably rusted completely during burial. It is also possible that the bronze blades originally had hilts of an organic material such as wood or bone, which has since decayed. The bronze hilts were married with the bronze blades by a modern restorer, consequently falsifying the archaeological record of the technology of sword-making.

The results call into question previously published analyses of swords of this type at the Hiroshima University and Okayama Orient Museum collections where, despite noting the weak junction of blade and hilt, it was concluded that the swords were intended as ritual objects [19; pp. 414–417; Figures 12–15]. It seems likely that other examples of this type of pastiche exist unrecognized in various collections. Accordingly, careful reassessment of any swords of this class that have bronze blades is recommended, as the present examination and analysis confirm that only some are wholly ancient and intact.

CONCLUSIONS

Iran is rich in metal resources and has a tradition of metalworking extending since at least the fifth millennium BC [31–33]. The working of bronze and iron, including the practice of casting bronze onto iron (for example in blades, axes and pins), became particularly highly developed in parts of western and north western Iran during the second and early first millennium BC, and are known both through excavation and finds circulating via the art market over the past century. Typological studies and archaeological reports provide a framework and better appreciation of the circulation of some of the main classes of object but the number of scientific analyses is still very small and a healthy degree of caution should be exercised over the interpretation of objects lacking archaeological provenance. The skills of Iranian craftsmen are not limited to antiquity and practical knowledge combined with personal gain has proved a powerful combination. As early as 1930, one Iranian dealer

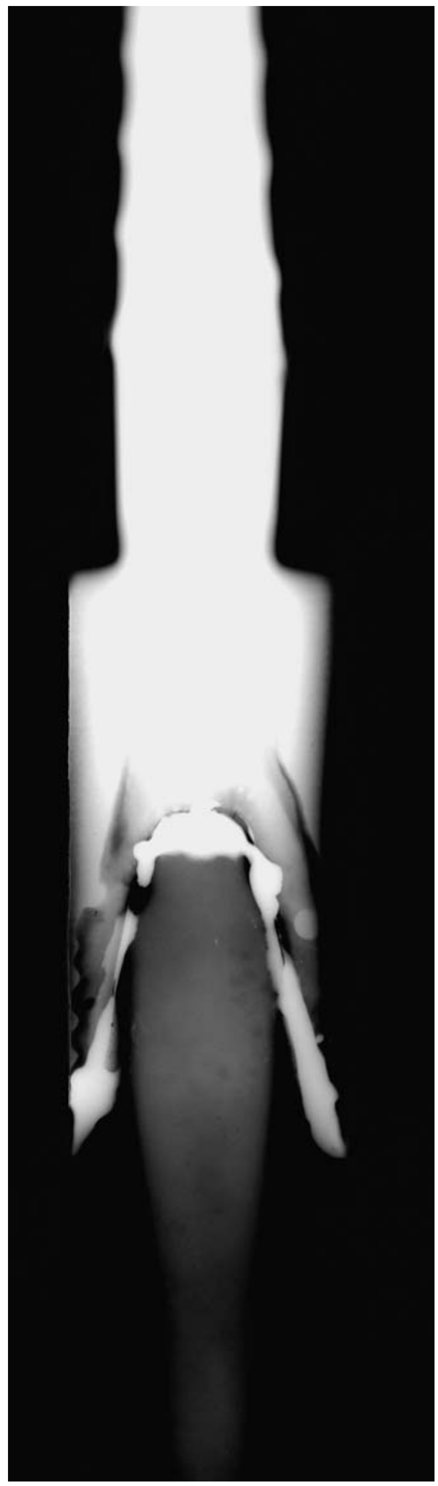

FIGURE 7. X-radiograph of the area where the hilt and blade join on the sword illustrated in Figure 6. Note the discontinuities and the white globular feature, which is soft solder

commented that "We have heard from Persia that there are a large number of 'Hittite' bronzes which are not authentic, in fact. They are modern forgeries, very recently made" [34]. The research scientist, Harold Plenderleith, working in the British Museum Research Laboratory, undertook some of the first authentication analyses of Iranian metalwork in the 1930s [35]. A small number of pastiches and a larger body of fakes have been recognized over the subsequent decades in different collections, but there are still traps for the unwary [10, 28; pp. 189–190; Nos 186–187, 36]. Nevertheless, scientific analysis continues to offer ways of detecting these objects, as the two case studies presented here illustrate.

Both of the swords from the British Museum collection examined here date to the beginning of the first millennium BC. The first belongs to a type of sword with a prominent cotton-reel pommel but where the original iron blade has been replaced by a bronze blade originally belonging to a different type of weapon. The second consists of a type of sword with a split 'ear' pommel. Here, scientific analysis proves that although some swords with bronze hilts – such as this example in the British Museum – were certainly cast-on to bronze blades and some excavated examples show the casting of bronze hilts onto iron blades, many others circulating on the art market show unmistakable signs of having the corroded iron blades replaced by bronze blades from separate weapons of the same typological class.

The material of the tang is critical to understanding the type of original blade. All sword and knife blades must extend as narrow tangs into their hilts if they are to be useable tools. Rather than being evidence for ritual practice, it is argued here that the so-called iron cores are simply all that remains of the tangs from blades that have been heavily tampered with on the art market. In every case, the use of X-radiography to determine the number and junction of the different elements was crucial, as was the use of XRF analysis to determine the different types of metal present and to help detect the presence of modern soft solders concealed by paint. With the benefit of these analyses it is now possible not only to reassess similar pieces in other collections but also to call seriously into question the existence of an ancient Iranian metalworking tradition that deliberately sought to create bimetallic objects with concealed iron cores.

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AUTHORS

St John Simpson (ssimpson@thebritishmuseum.ac.uk) is a curator in the Department of the Middle East and Susan La Niece (slaniece@thebritishmuseum.ac.uk) is a scientist in the Department of Conservation and Scientific Research, both at the British Museum.

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