

Bronze-Hilted Iron Swords from Western Asia at the Department of Archaeology, Hiroshima University

**Hisashi NOJIMA, Yui ARIMATSU, Masahiro FUJII, Susumu MURATA,
Hakuhiro ICHIKAWA, Shohei FUJII, Naoto MORIMOTO**

1. Introduction

If you take the central stairwell in the research wing of the Hiroshima University Department of Archaeology up to the second floor, you will find bronze-hilted iron swords on display. The Research Centre of the Hiroshima University Faculty of Letters purchased them in Iran during the 1970s. The book *Sogen no Michi* (Grassland Road: Archaeological Research in Iran) which was published in 1973 by the Hiroshima University Archaeological Mission, contains photographs of these swords.⁽¹⁾ There is no detailed explanation of these artefacts; it simply states that they were excavated in Azerbaijan, and their total lengths are shown.

In this paper, we will present eight complete bronze-hilted iron sword specimens that include those regarded as bronze swords with an ‘iron core’ (bimetal bronze swords). Running through the centre of the grip is an iron core. In some of the swords, this iron core runs through the grip to the pommel. As discussed below, it is now considered highly likely that this iron rod is the remainder of what was once the ‘tang of an iron sword’. For this reason, we will present these specimens as bronze-hilted iron swords. While referring to observations of the material, including a four-year long physical and chemical analysis conducted with Professor Kiyoshi Shizuma of the Hiroshima University Graduate School of Engineering (currently, specially appointed professor) (Shizuma et al. 2015), we will clarify problems in the materials which stem from the fact that the swords were purchased from the antiques marketplace. We will then solicit the guidance of knowledgeable scholars and discuss their findings.

2. Introduction of the Bronze-Hilted Iron Swords Held in Hiroshima University

(1) Bronze-Hilted Iron Sword 1 (Image 1:1, Figures 1:1, 2:1)

This sword is comprised of an iron blade and its tang, which is enveloped by a guard, grip, and pommel, all of which are bronze. The full length of the sword is 57.0 cm, the blade length is 43.0 cm, whose widest connecting part is 4.7 cm, the grip is 7.2 cm and the sword’s current weight is 527.6 g. The width of the blade’s base is 3.2 cm, decreasing gradually towards the tip. The centre has a thickness of approximately 7 mm. It has a spine in the centre, and the cross section is vaguely diamond-shaped, although the base is flat. Three lines are engraved on each side of the blade, and two lines extending out from these lines near the base resemble the kanji character 八. The iron blade is held by a bronze guard shaped like the Japanese kana コ, and the cross section where the guard and blade are joined is almond-shaped. The width of the grip is 1.6 cm, and its cross section is roughly

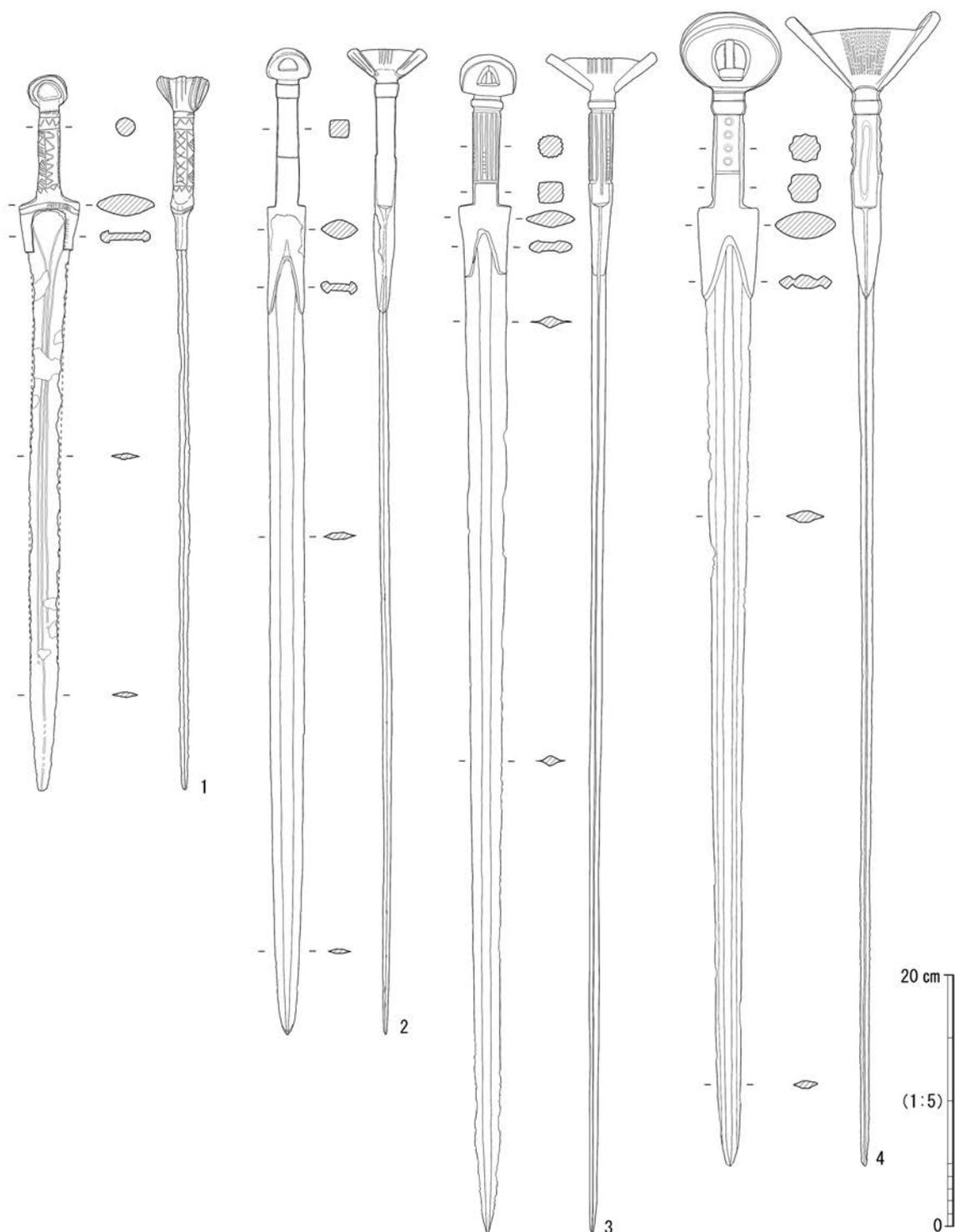
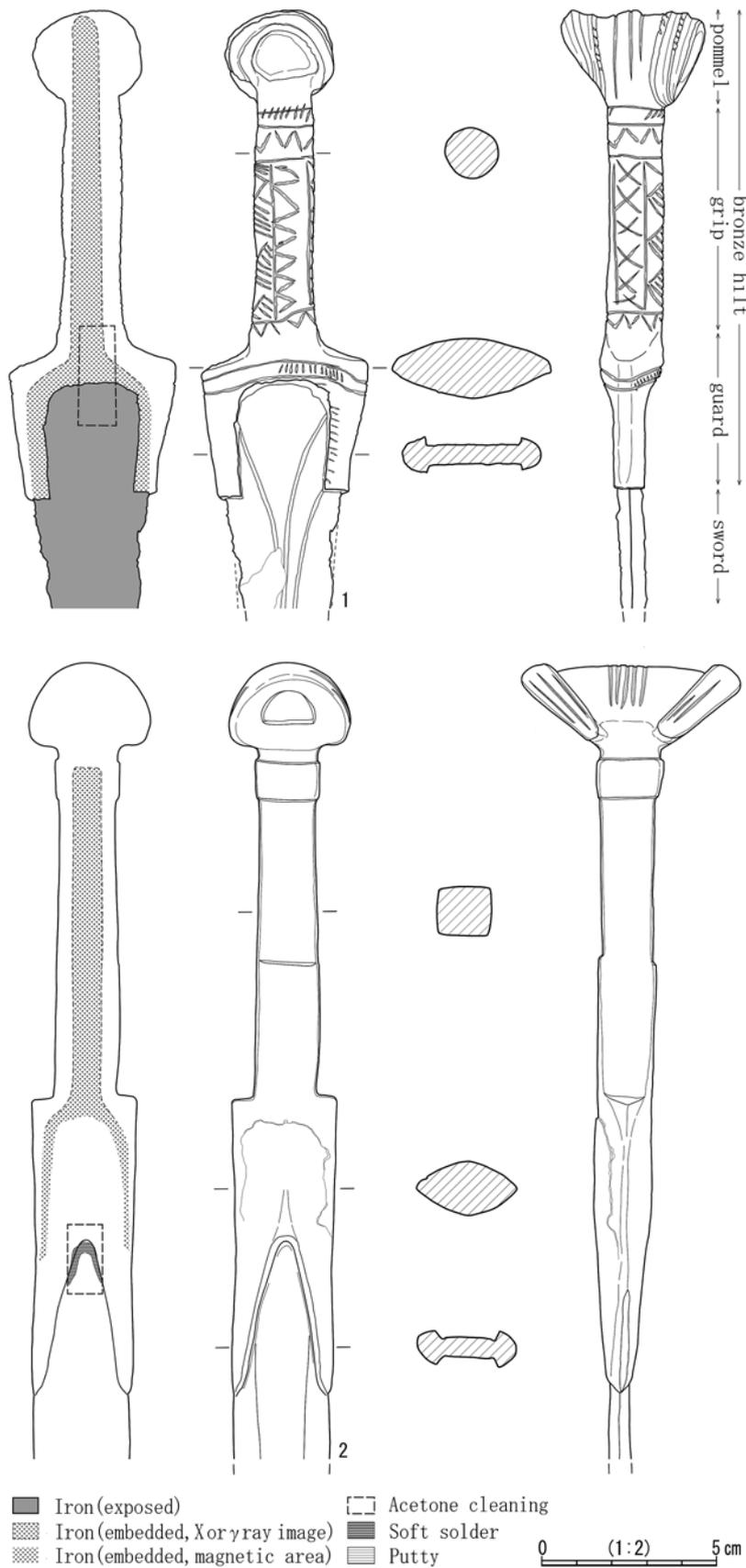


Figure 1. Full view of bronze-hilted iron swords (Bronze-Hilted Iron Swords 1-4)

circular. The pommel is distinctive for having a split ear shape (hereafter, we refer to this as the split 'ear' pommel). Two concavities about 5 mm deep are molded into each flank of the pommel.

A pattern is engraved in the area covering the guard to the pommel. Engraved onto the guard is a pattern composed of incisions intersecting with the inner edge, and two parallel linear incisions. The



grip is demarcated with four lines running lengthways along the grip all the way to the pommel base, and three linear incisions running across the grip, all of which combine to form a zig-zag and slanting lattice pattern. Three lines are engraved into the central area of the pommel's upper side. There are also incisions on each of the two raised areas molded at both ends of the 'ear'.

The blade and grip are off-centre. This can also be confirmed in the X-ray⁽²⁾ (Image 3:1). The fact that the tang protrudes from the end of the pommel also suggests that a mold was set on the pommel so the tang could be inserted, and then molten bronze could be poured in. It is impossible to recognize any traces joining the guard to the pommel. It is not entirely inconceivable that the pattern strip demarcating the grip from the pommel

Figure 2. Enlarged view of grip (Bronze-Hilted Iron Swords 1 and 3)

was designed to hide joining traces, but because the width remains the same between the upper and lower parts, it is reasonable to assume that the grip and pommel were created from the same mold. Professor Shizuma points out that a gamma ray irradiation scan has revealed the hint of elliptical shapes, suggesting that pores may exist around the tang (Shizuma et al. 2015).

(2) Bronze-Hilted Iron Sword 2 (Image 1:2, Figures 1:2, 2:2)

The full length of the sword is 78.5 cm, the blade length is 57.2 cm, the widest part of connecting section is 3.0 cm, the grip length is 10.1 cm and its current weight is 927.5 g. The blade is slightly misshapen around the base, and is not fully aligned with the grip. Viewing the blade directly, it has an even width of 2.7–2.9 cm up to 70% of its entire length. After this point, the blade then gently tapers off towards the tip. The centre has a thickness of 7 mm, and the area around the blade base and tip have a thickness of 5 mm. The flat area in the middle between the surface and back of the blade is around 1 cm in width, becoming broader around the base of the blade. The part of blade between the flat area and both edges is slightly concave and then continues to the blade edges. The guard has a depression forming a V-shape, and it leads to the grip at a right angle. It is also possible to see fissures over a wide area, apparently the result of internal pressure (Figure 3). A cross-sectional view of the guard shows a roundish, diamond shape, while the grip has a square shape. The guard and grip have a simple design: there are only some grooves on the raised area around the centre of the grip and the part leading to the pommel. Fixed onto the grip is an ear-shaped pommel, which has shallow semi-circular concavities molded into both flanks. Both the ends and upper surface of the pommel are engraved with two to five linear incisions thought to have been made after the casting.

Observation with the naked eye reveals that part of the juncture of blade and guard has undulations resembling a connecting portion. There are also traces of chipping, suggesting that an attempt was made to synchronise the width of both components. We therefore cleaned the area with acetone⁽³⁾. As a result, a dark green substance that we had initially thought was an eroded patina, was revealed as a soft solder (Colour illustration 2:2)⁽⁴⁾. From this finding, it is clear that the dark green oil-based paint that melts away with acetone had been applied over the soft solder.



**Figure 3. Crack in guard
(Bronze-Hilted Iron Sword 2)**

When we used a magnet to search for the iron rod, we found that the area from the guard to around the grooves on the grip was magnetised. In addition, the magnetic reaction around the guard suggests that the iron rod branches out in two directions, instead of passing straight through the centre. Therefore, it is highly likely that the specimen's iron rod forms a Y shape. The fissuring in the guard mentioned above corresponds with the intersection of the rod's two branches, suggesting that it was caused by pressure from

inserting the blade. The γ -radiograph confirms the presence of many pores in the area between the guard and grip, but none is seen in the blade (Image 3:2). Even if we allow for the fact that some parts were hollowed out due to corrosion of the iron rod, it is still reasonable to assume that the blade has a different composition from the rest of the sword. Considering all the above findings, it is highly probable that the grip and pommel were prepared separately from the blade, and then fitted onto the blade later.

(3) Bronze-Hilted Iron Sword 3 (Image 1:3, Figures 1:3, 4:3)

The full length of the sword is 94.4 cm, the blade length is 82.3 cm, the widest part of connecting section is 4.2 cm, the grip length is 12.1 cm and its current weight is 1337.3 g. The width of the blade's base is 3.4 cm, the thickness is 1.0 cm, and the width and thickness gradually decrease towards the tip. The cross section has a round-edged diamond shape, and a central spine protrudes and then extends towards the blade edge, forming a shallow basin along the way. The guard is V-shaped, and a small crack is visible on part of the border between the guard and blade. The cross-sectional view of where the grip and blade meet reveals a round-edged diamond shape, leading to the guard at a right angle. The grip is partitioned from the guard by a broad engraving, and the cross section of the grip portion between the engravings and guard is square, whereas the cross section of the part near the pommel is square without sharp corners. Considering that the grip and pommel are partitioned by grooves, and the thickness differs on each side of the grooves suggest that they were cast separately.

Sixteen straight lines, at intervals of 2 mm, can be seen between the engraving and the grooves. The lines extending towards the blade edges cut across the engraving that marks the partition and stretch a further 1 cm towards the connecting part. The pommel is ear-shaped at both ends, and six straight lines are engraved into its upper surface. There are also burrs around the lines that were probably created when the lines were engraved.

Holes at each flank of the pommel indicate the presence of an iron rod that passes completely through to the saddle-shaped part (Figure 5). The magnet gave a positive response along the contours of the grip and guard, suggesting that the iron rod passes through them and branches off to form a Y shape. Furthermore, cleaning the sword with acetone revealed the presence of soft solder on the border between the blade and guard (Colour illustration 2:3). Given the presence of soft solder and the aforementioned cracks in the blade and guard, we conclude that the two components were joined in this area.

(4) Bronze-Hilted Iron Sword 4 (Image 1:4, Figures 1:4, 4:4)

The full length of the sword is 92.0 cm, the blade length is 73.4 cm, the widest part of the connecting section is 3.6 cm, the grip length is 9.4 cm and its current weight is 1260.4 g. The width of the blade's base is 3.6 cm, the thickness is 1.2 cm, and the width and thickness gradually decrease towards the tip. The central spine has a flat surface approximately 5–7 mm in width that extends towards the blade edge forming a lobe. The guard has a roundish V shape and leads to the grip almost

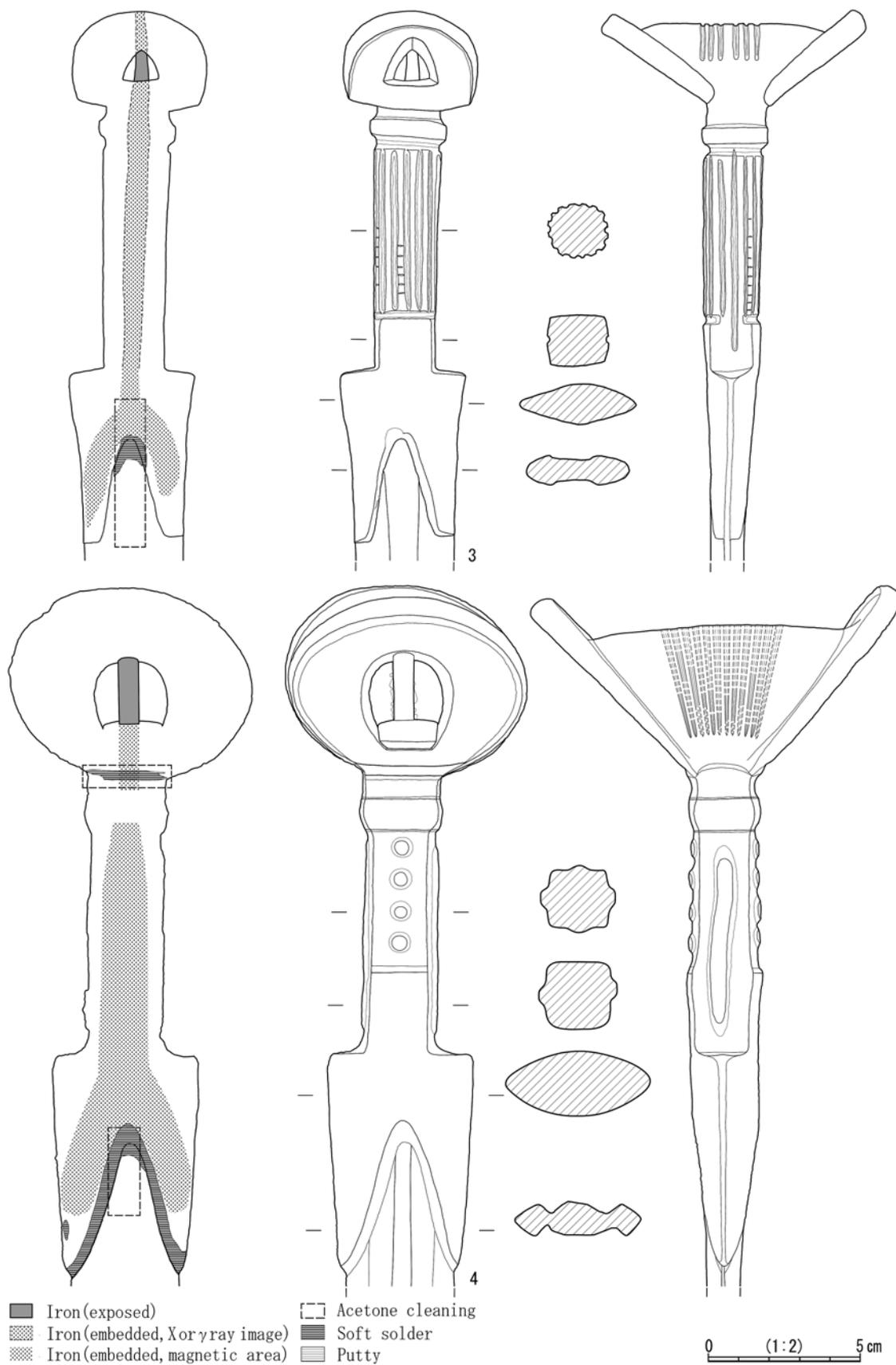


Figure 4. Enlarged view of grip 2 (Bronze-Hilted Iron Swords 3 and 4)

at a right angle. A cross-sectional view of the grip reveals a round-edged square. There is a raised area leading towards the guard, and there are grooves on the area forming a border with the pommel. There are round reliefs 5 mm in diameter between the raised area and grooves: four each on the front and reverse surfaces, and protrusions are also visible on another surface. Since the ear-shaped pommel is large, the extraneous matter obscures it, but there appears to be twelve straight lines approximately 1–2 mm wide etched into the upper surface. A hole penetrates through the pommel, exposing the iron rod (Figure 6). Additionally, a bronze board about 3 mm thick cuts into the iron rod.

According to an X-ray, the permeability of the border between the blade and guard is lower compared to other areas such as the grip that is thicker (image 3:4). Cleaning the sword with acetone showed the presence of a dark green patina and soft solder in this area (Colour illustration 2:4). Traces of buffing were confirmed in the soft solder and the adjacent bronze work. We can therefore state that the area was smoothed after the soft solder was applied. The acetone swab also revealed the same dark green patina and soft solder around the juncture of the grip and pommel (Colour illustration 2:4). It is conceivable that a separately cast pommel was fixed onto the grip, but considering that the soft solder in the juncture was only found in two places, and the grip and pommel both envelop the rod, it is highly likely that this combination was created in the original cast.

(5) Bronze-Hilted Iron Sword 5 (Image 2:5, Figures 7:5, 8:5)

The full length of the sword is 83.7 cm, the blade length is 65.0 cm, the widest part of the connecting section is 3.8 cm, the grip length is 8.9 cm and its current weight is 1215.2 g. The width of the blade's base is 3.5 cm, and the width gradually decreases toward the tip. The centre has a thickness of around 9 mm, the cross section is a spindle shape, and the blade shows no clear signs of grinding. The guard has a roundish U shape and multiple types of patterns can be seen towards the grip. The cross section of the area around the base is elliptical. The cross section of the

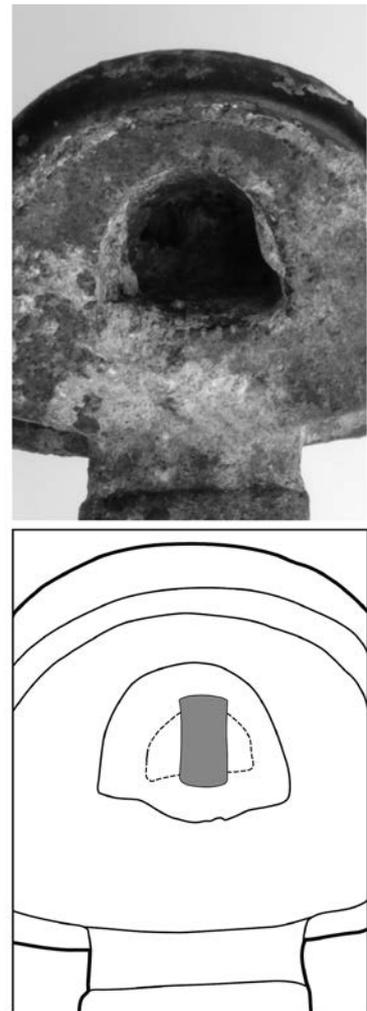


Figure 5. Iron rod visible on the side of pommel (Bronze-Hilted Iron Sword 3)



Figure 6. Iron rod visible on the side of pommel (Bronze-Hilted Iron Sword 4)

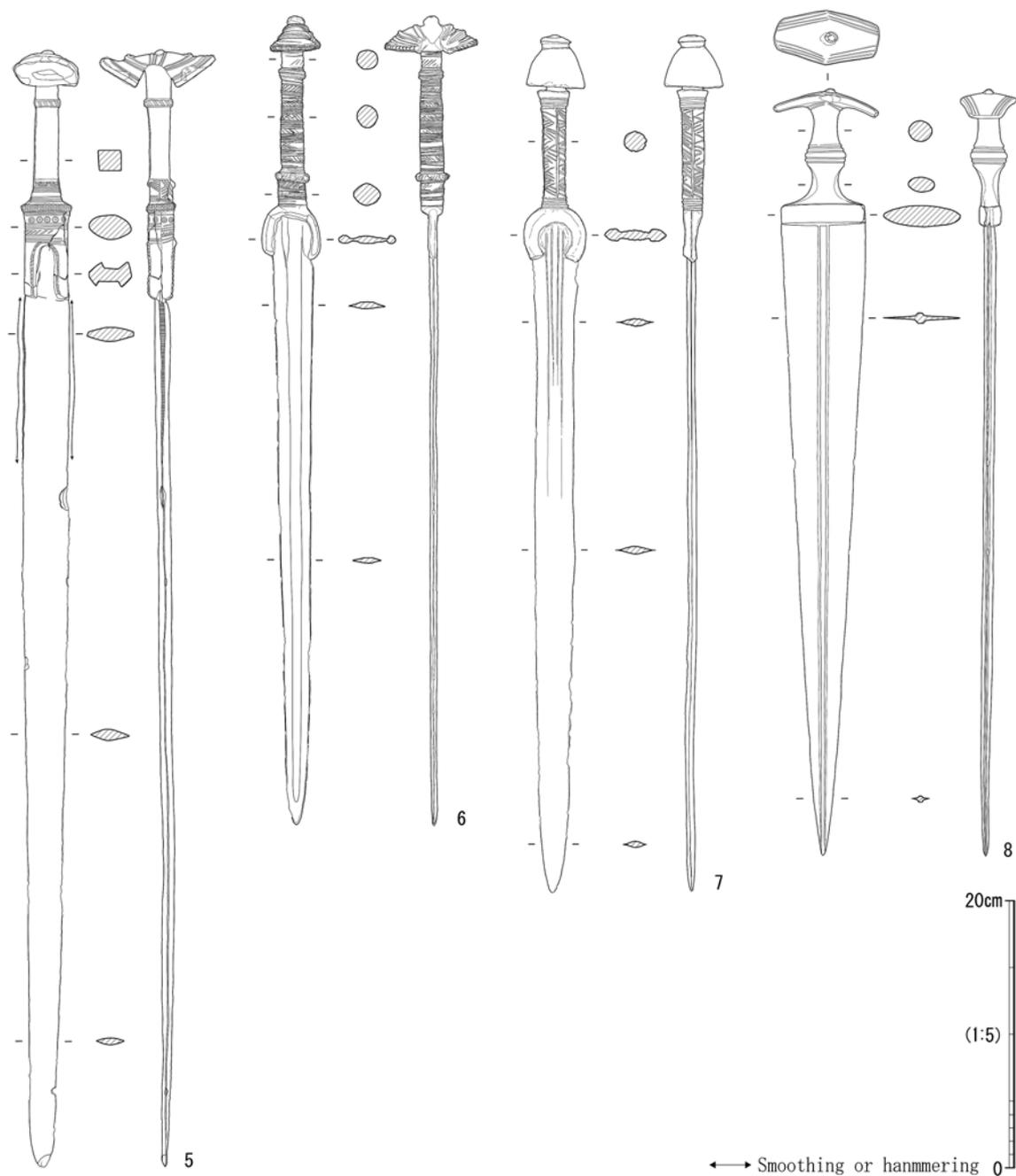


Figure 7. Full view of Bronze-Hilted Iron Sword 1 (Bronze-Hilted Iron Swords 5–8)

grip is oblong, and is divided into upper, middle and lower sections by grooves created through casting. Whereas the grooves on the guard side are only present on both the front and reverse surfaces, grooves on the grip side run around the whole circumference. The pommel is comprised of two ear shapes and a saddle shape that connects the two ‘ears’. The hole on the flank does not penetrate fully, and the iron rod can just about be seen from above.

The inner edge of the guard contains indentations. Engraved into the base are two to four straight incisions, slanted incisions and double circles, and engraved into the connecting part is an extremely

fine slanting lattice. Patterns on the front and reverse of the guard are separated, but the lattice pattern runs along the whole circumference. Slanting patterns are engraved on each groove on the grip. The grip's lower section has a combination of patterns not seen in the other two sections. The front and reverse surfaces of this section are engraved with straight lines. The sides are engraved with straight lines in the middle and slanting lines leading to the left and right. The pommel has an iron border that is engraved with two straight lines on the end, two straight lines along the graded protrusion and five straight lines on the upper side.

A sizeable crack was observed in the guard that likely resulted from pressure from the blade side. Cleaning the area with acetone revealed a number of places in the U-shaped part of the guard where it appears that fragments had broken off and then been re-fixed with putty (Colour illustration 2:5). An oil-based dark green paint approximately 1–2 mm thick was applied in some places in order to conceal the putty, and accordingly, the pattern is missing in some places. Around 12 cm of both sides of the blade have been whetted down to decrease the width, possibly to match the blade's base with the guard. The X-ray image reveals that the iron rod seen in the pommel when viewed from above runs completely through to the guard (image 3:5). In addition, the sphere of magnetisation suggests that the iron rod branches off in line with the guard to form a Y shape.

(6) Bronze-Hilted Iron Sword 6 (Image 2:6, Figures 7:6, 8:6)

The full length of the sword is 60.4 cm, the blade length is 45.2 cm, the widest part of connecting section is 2.9 cm, the grip length is 13.6 cm and its current weight is 661.2 g. The width of the blade is approximately 3.0 cm, and gradually decreases towards the tip. The centre has a thickness of around 4.5 mm, the middle spine has a flat surface on the front and rear roughly 1 cm in width and both ends extend towards the blade edge forming a shallow lobe. This lobe becomes more distinct towards the base.

The guard is U-shaped and the grip has two sets of grooves. The set of grooves on the blade side (set A) comprises six circular projections approximately 4 mm in diameter, as well as slanted engravings. The set of grooves on the grip (set B) comprises two incised lines. The grip contains nine pattern strips formed of two to five incised lines, and engraved in between them are slanting lines and slanting lattices. Both ends of the pommel are fitted with a slightly deformed ear shape.

The cross-section of the area encompassing the U-shaped guard and groove set A is a rough, diamond-shaped ellipse, and the slanted engravings are dense and well-defined. However, the pommel side's cross-section is much more circular than groove set A, and the engravings are more blunt. It is therefore possible to assume that the area encompassing the base of the guard and groove set A was one component. The X-ray fluorescence analysis showed that the ear-shaped parts of the pommel have a markedly different metallic composition (Shizuma et al. 2015), suggesting that one of the two was repaired by someone from a later generation. The presence of an iron rod approximately 4 mm in diameter was confirmed on the upper side of the pommel, and the rod's tip appears to have

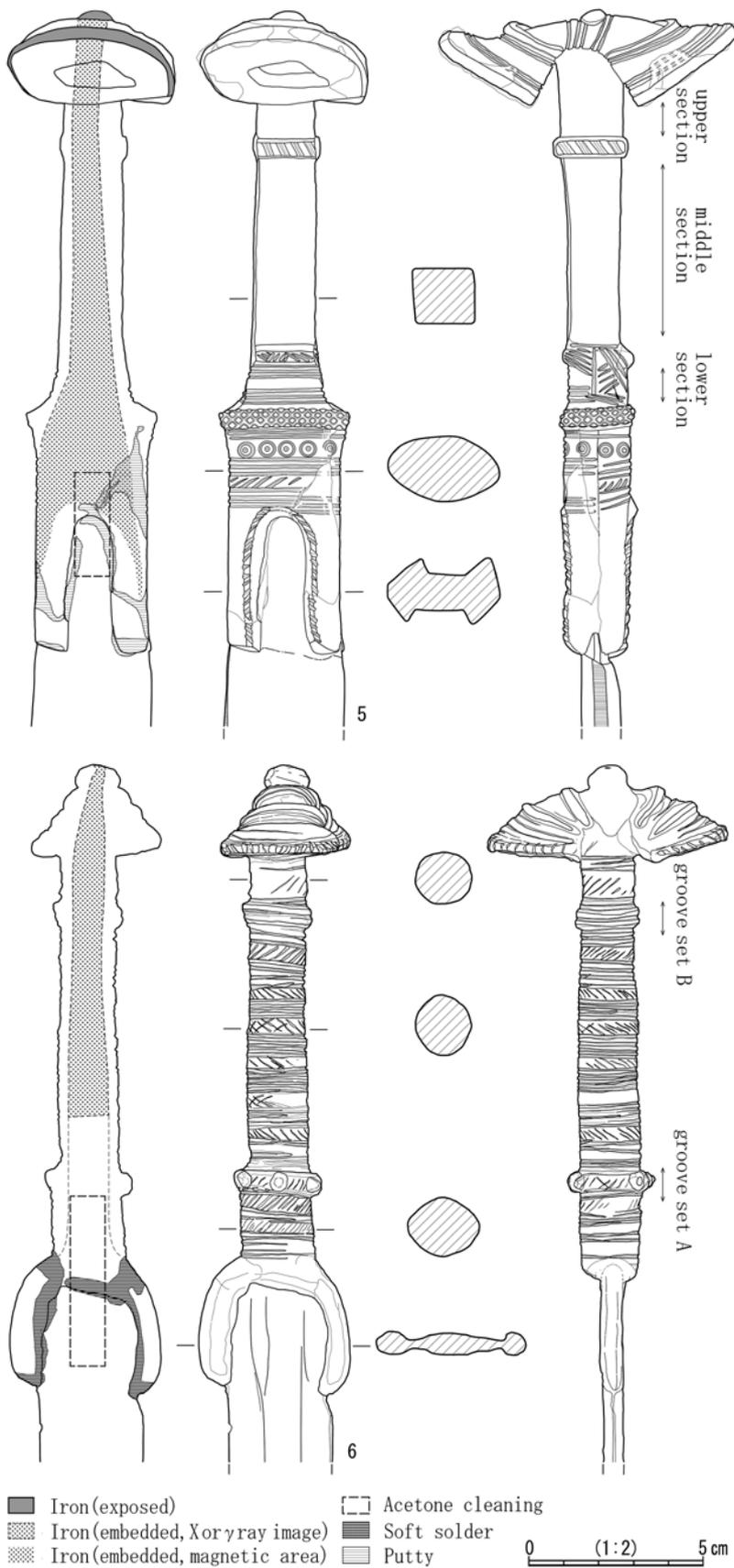


Figure 8. Enlarged view of grip 3 (Bronze-Hilted Iron Swords 5 and 6)

been fit with a bronze ring approximately 11 mm in diameter. Note that the blade's edge around the base has been destroyed as a result of beating and hammering. It appears that the blade was narrowed slightly to align it with the guard.

The X-ray fluorescence analysis (Image 3:6) confirmed that the iron rod runs all the way from the pommel to the U-shaped guard. The sphere of magnetisation also strongly suggests that the rod does not fork in two to form a Y shape. It was also revealed that the inner side of the U-shaped guard is covered with a metal that is impenetrable by X-ray. The dark green paint on the U-shaped guard came off after cleaning with acetone, showing the presence of soft solder (Colour illustration 2:6). Soft solder was also detected from the end of the grip to the guard's shoulder. This soft solder was apparently applied to

meld the two together. The soft solder was not detected prior to cleaning, so the area must have been painstakingly coloured using an oil-based paint.

(7) Bronze-Hilted Iron Sword 7 (Image 2:7, Figures 7:7, 9:7)

The full length of the sword is 63.1 cm, the blade's length is 46.2 cm, the widest part of the connecting section is 4.5 cm, the grip length is 16.9 cm and its current weight is 806.0 g. The blade width is approximately 3.5 cm, and after making a gentle, inwardly-curved line 3.2 cm from the connecting part, the width remains the same until 60% of the entire length and then gradually narrows towards the tip. The centre has a thickness of approximately 6 mm, the cross-sectional view shows an almost convex lens shape, and a gentle lobe appears around the edge near the tip. Both the front and reverse sides of the spine are engraved with four linear incisions running from the base to tip.

The guard is U-shaped. A cross-sectional view reveals roughly square ridges around the blade part, which make an outwardly curved line that narrows towards the two ends. The grip has a vaguely circular cross section, but the diameter increases marginally towards the pommel. The entire grip is covered by engravings with linear patterns. The guard and pommel are bordered by three incised lines. The area between these two parts is partitioned into roughly equal sections by four incised lines, and these sections are engraved with rather irregular slanting lines. There is a gap between the grip and pommel, and it is possible to see a bronze component running through the pommel linking the two together. The grip is slightly off-centre from the pommel. The pommel has a truncated cone shape and was probably made from limestone. This component was fixed in place by a bronze fastener on the end.

In the joining part between the blade and guard, it is possible to make out an open seam, which appears to be a juncture. The dark green paint on the sword's base dissolved as a result of cleaning with acetone, revealing the presence of soft solder (Colour illustration 2:7). This oil-based paint was probably applied in order to hide the soft solder. The blade base is lacking an edge section. It is possible that this section was altered intentionally to match the widths of the guard and blade. This being the case, it is highly likely that the blade was cast separately from the rest of the sword and that both components were fitted together at a different time from casting. The X-ray (Image 3:7) also shows the presence of a different type of metal adhering to almost the entire inner surface of the guard. Even the parts of the sword that were not cleaned with acetone exhibited traces of joining by heavy metals.

The X-ray also confirmed the presence of a rod-shaped silhouette inside the grip. The rod is angled slightly against the grip, probably unintentionally, apparently corresponding to the misalignment of the grip and pommel. When we ran a magnet along the grip and guard, it responded positively along the entire grip and also the guard's contours. It can therefore be surmised that the grip contains an iron rod branching off to form a Y shape.

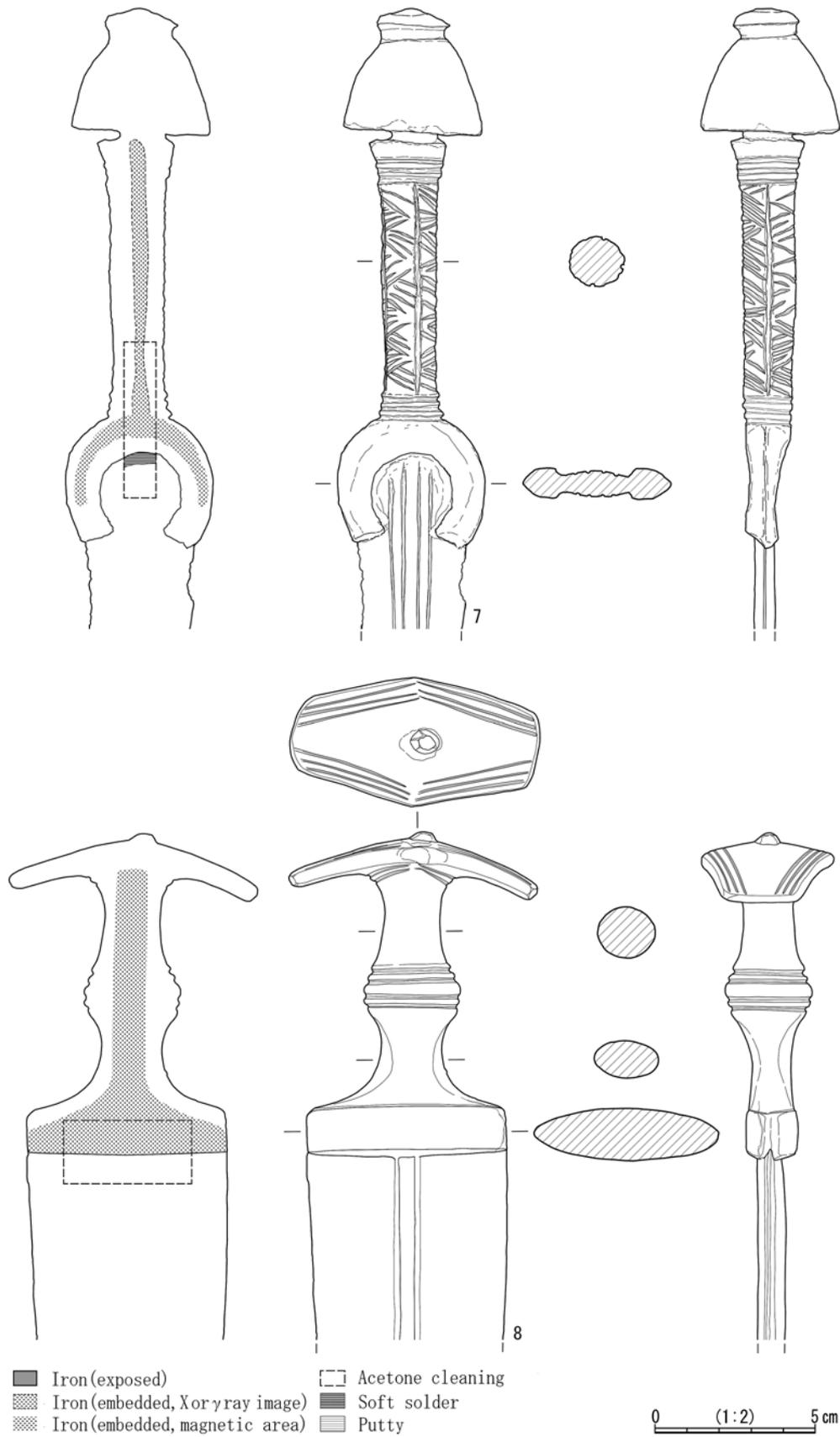


Figure 9. Enlarged view of grip 3 (Bronze-Hilted Iron Swords 7 and 8)

(8) Bronze-Hilted Iron Sword 8 (Image 2:8, Figures 7:8, 9:8)

The full length of the sword is 57.2 cm, the blade length is 47.2 cm, the widest part of the connecting section is 6.2 cm, the grip length is 7.7 cm and its current weight is 837.0 g. The blade width around the base is approximately 6.2 cm at most, and gradually decreases towards the tip. A cross-sectional view reveals a trapezoidal spine running down the centre, and an almost flat edge continues from each end. The thickness is 6–8 mm at the spine, around 2 mm at the edge and the thickness decreases towards the tip. The guard has an elevated area on the border it shares with the grip, a cross-sectional view of which reveals an oblong shape. There are fissures on part of the guard, and it is possible to discern a channel on the flank that was apparently designed to receive the blade. A gently curving line extends from the guard and reaches to the grip. The grip has a knobbly swelling at the centre encircled by four incised straight lines. A cross-sectional view reveals that the two sides of the grip partitioned by this swelling differ in shape: the guard side is oblong-shaped, and the pommel side is almost an accurate circle. The end of the grip is affixed with a pommel comprising an arched hexagonal board. The pommel has a projection on its upper surface, and engravings on the front and rear surfaces. The central axis of the grip and projection on the pommel's upper surface are misaligned, and so it is reasonable to assume that both components were cast separately.

Referring to the X-ray (Image 3:8), we ran a magnet over the sword. This confirmed the presence of an iron rod running from the grip to the guard, which along with having a flat shape, forms a T-shape. The blade and guard are currently broken apart, making it possible to confirm the presence of soft solder at the juncture (Colour illustration 2:8). In view of the sword's durability, it is unlikely that it originally had this structure. It is apt to assume that the sword's original iron blade was broken off and that a bronze blade was subsequently refitted. It may be surmised that the crevice in the guard's flank was formed during this insertion.

3. Overview of Research on Bronze-Hilted Iron Swords from Western Asia: The Academic Recognition of Bronze Swords with an “Iron Core”

(1) The Iron Age in the Northern Middle East

The beginning of the so-called Iron Age in the mountains on the south side of the Caspian Sea (Figure 10) has been traced back as far as the mid-15th century BC (Haerinck 1988; Dyson 1965, 1989a; Young 1964, 1967). However, it should be noted that what distinguishes the Iron Age from the Bronze Age is not the use of iron or the establishment of iron smelting, but rather the changes in ceramics (Medvedskaya 1982; Mousavi 2001; Young 1964, 1967) and the presence/absence of settlement continuity in index sites (Dyson 1977, 1989b; Young 1985). The substantial use of iron tools did not begin in this region until the 13th century BC (Piller 2008). The emergence of bronze-hilted iron swords is an indicator (Miyake 1976; Haerinck 1988). Until the emergence of such swords, all cutting tools were made from bronze, and the existing ironwares were small ornamental items like

bracelets (e.g. Dyson 1989a). Therefore, upon the emergence of what would later become the universal cutting tool, namely iron swords, it was a momentous phenomenon even if it was limited in terms of quantity.

Thus, the focus of discussion has been the origin of the ‘bronze-hilted iron sword’ and its phylogeny. Even in the northern Middle East, which has produced many metal products over the course of its history, no one has discovered the prototype of the bronze-hilted iron sword. All the excavated examples approximately similar chronologically have invariably been reported in north-west Iran or the Caucasus (Figure 10; cf. Adachi 2012; Moorey 1991)⁽⁵⁾. If early iron products originated in these regions, this would present a major challenge to the established theory on the emergence of iron smelting in Eurasia, which is known as the Hittite monogenesis theory (Kontani 2001a: 24–25; 2002). At the same time, such a phenomenon might also help advance research on the early Iron Age period of this region, which is currently undergoing a transition in terms of the division of the aforementioned Iron Age, for example (cf. Burney 1994; Mousavi 2008; Muscarella 1994).

(2) The “Discovery” of the Bronze Sword with “Iron Core” and Doubts about It.

A major contribution to this discussion came in the early 2000s with the “discovery” of the bronze sword with an “iron core” (bronze sword containing rod-shaped iron) (Kontani 2001a, b). The

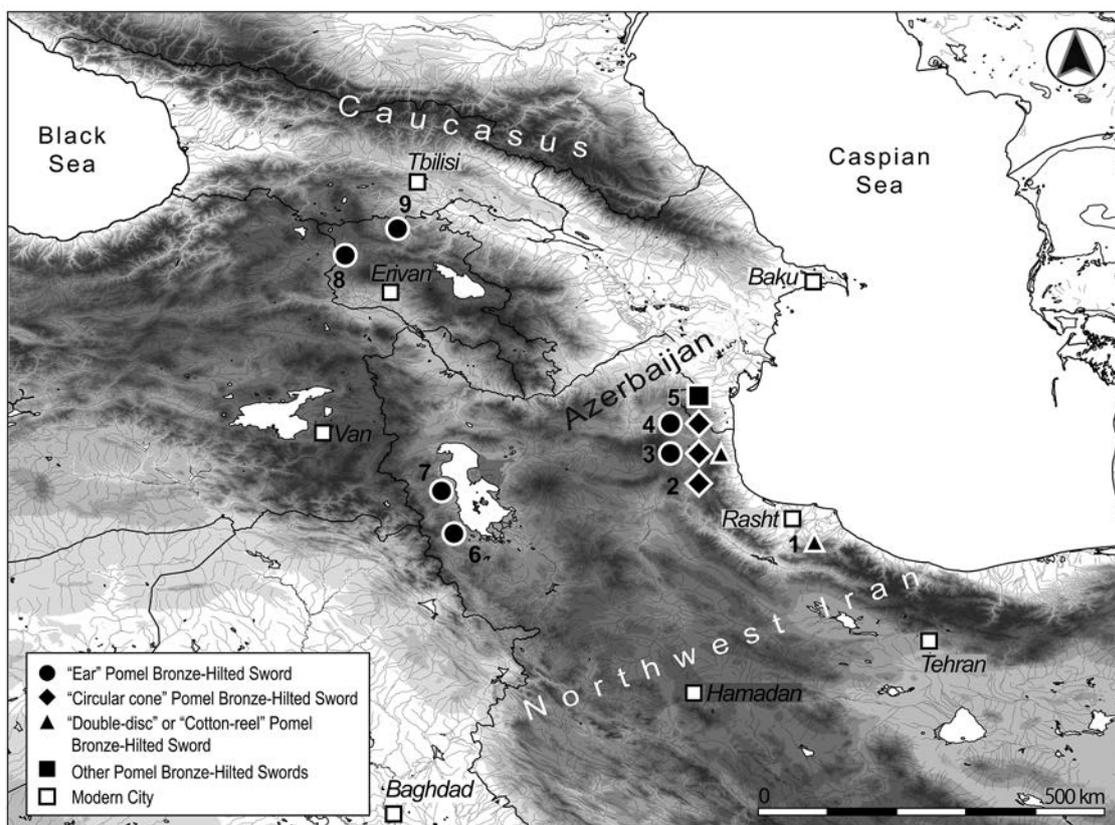


Figure 10. Distribution of sites where bronze-hilted iron swords have been excavated

1: Ghalekuti II, 2: Agha Évlar, 3: Toul, 4: Chagoula Dere, 5: Hivéri, 6: Hasanlu, 7: Geoy Tepe, 8: Ani, 9: Tsalka.
(Typology of bronze-hilted iron swords shown in the legend is based on Tsumoto 2002)

assertion that the hilt of the sword houses a ferrous rod component had already been made, but it aroused only sporadic interest (e.g. Moorey 1971: 78–79; Wever 1969). The “discovery” of a number of such specimens established the view that it is highly likely that there exists many such swords which appear on the outside to be bronze, but are in fact bronze swords with an iron core’. Since then, the “bronze sword with an iron core” has been established as a single typological class and was subsequently taken up by Japanese researchers as a serious topic of discussion.

The bronze sword with an iron core falls under the category of a bimetal sword, but in terms of the iron’s function, it differs fundamentally from the aforementioned bronze-hilted iron sword, which has been regarded as the quintessential bimetal ware. Therefore a structural comparison with bronze-hilted iron swords seemed to suggest that the bronze sword with an iron core type may be the antecedent to the bronze-hilted iron sword type based on technological considerations (Kontani 2001a). The morphological variation of bronze swords with an iron core that has been clarified thus far appears to be related to the bronze-hilted iron sword (Adachi 2012a: 104–105; Kontani et al. 2002; Kontani 2005). Having the outward appearance of being wholly bronze, but enveloping rod-shaped iron in the grip or in some cases from the grip through to the pommel, is a characteristic shared by a number of different sword types classified according to the pommel form. It is also suggested that many of these pommels have features common to bronze-hilted iron swords (Adachi 2012a: 118, Table 4; Tsumoto 2002: 10). At the same time, since the ‘pommel types seen on bronze swords with an iron core have ornamentation that closely resembles that of the Caucasus’ (Kontani 2002), it has been asserted that ‘the beginning of iron culture, in which the origin of the bronze swords with an iron core takes part, should be sought in the Caucasus region (ibid.).

To concretely verify this assertion, it is essential to determine the chronology of the bronze sword with an iron core and study its phylogeny. Typological and chronological sequencing was therefore conducted on a group of swords sharing the distinguishing feature of an ear-shaped (saddle-shaped) pommel (‘ear pommel sword’). These swords were appropriate for analysis on account of their numerical and morphological richness (Adachi 2002a, 2012: 106–122; Adachi 2002b). Based on a morphological comparison with bronze swords excavated in Mesopotamia and western Iran, the swords have been dated to between the end of the second millennium BC and the 8th century BC. The period of the swords’ duration was identified based on the various stages of typological change, such as the increase in sword size and simplification of the guard. At the earliest stage, there are no bimetal products like bronze swords with an iron core or bronze-hilted iron swords; all that exist are bronze-hilted bronze swords with no iron core. Both of these of bimetal sword types existed concurrently from around the middle stage on and continued existing together until the final stage. It is highly significant that whereas all specimens from the earliest stage were excavated only in northwest Iran, the bimetalisation that takes place in the subsequent stage occurs in tandem with the expansion of manufacturing regions towards the Caucasus. While not explicitly stated as such, this finding was

considered to indicate once again the region's importance at the time of the introduction and use of ironware cutting tools.

But the main factor preventing more in-depth research into bronze swords with an iron core (including the reason why their function cannot be specified) is the lack of excavated material. Most of the theories put forward have been based on items purchased from antique markets. This is because no excavated examples exist of the bronze-hilted bronze sword with 'iron core'.

For archaeology, which by definition analyses and examines excavated materials, the dependence on purchased artefacts will always be a weakness. While the research on bronze swords with an iron core raised enthusiasm, it was clearly inevitable that analytical results would cast doubt on the swords' reliability as archaeological materials (Simpson & La Niece 2010). One such example was a chemical analysis conducted on the grip and blade, the results of which indicated that the components themselves were indeed ancient (*ibid.*, 96). However, X-rays revealed that some specimens have a form looking like mosaic and that the 'iron core' was only present in the pommel and not in the lower section of the hilt (*ibid.*, 97, Fig. 3). Furthermore, after carefully examining the material's surface using acetone and an ultraviolet scan, a dark green coating resembling patina was detected on the grip and blade base (*ibid.*, 97–98). It appears that this was brushed on to conceal the traces of joining, especially on the soft solder that joined the grip and the blade base (*ibid.*, 97, Fig. 7). As mentioned above, the presence of the soft solder itself was also seen in preceding studies, but it was regarded as a technical feature of the bronze swords with an iron core, and not treated as a particularly important issue. However, the fact that the soft solder is accompanied by the oil-based paint forces us to consider a different possibility.

A comprehensive consideration of the verification analyses suggested that the components of the bronze sword with an iron core, namely the grip and blade, and sometimes the pommel as well, did not originally belong together and were merged at a later time (*ibid.*, 96). An even more significant conclusion is that the original blade was iron, not bronze (*ibid.*, 96). It is conceivable that long-term change in the earth resulted in corrosion of the iron blade and the loss of much of its aesthetic value. It is also possible that the blade completely rusted away. Accordingly, in order to increase the commercial value in the antique market, the swords would have been refitted with blades of bronze, for which demand is high, and then distributed as bronzeware swords. The part of the iron blade's tang remaining in the hilt was left in because its presence would not affect the commercial value. Consequently, bronze swords with an iron core emerged on the market (*ibid.*, 99–100). In summary, it was concluded that the iron bar in the hilt traditionally dubbed the 'iron core', is actually all that remains of the original iron blade's tang (*ibid.*, 99–100).

It is certainly true that in the case of ear pommel swords, upon which the above-mentioned chronological sequencing was based, the specimens for which the region of excavation and material properties can be determined include only bronze-hilted iron swords. Specimens that could possibly

be bronze swords with an iron core (i.e. bronze-hilted bronze swords) are themselves not very numerous (e.g. De Morgan 1925: Fig. 251. 2–4; Gambaschidze et al. 2001: 406; Maxwell-Hyslop 1946: Pl. 39. 2; Schaeffer 1948: Figs. 232. 3–4, 12, 271. 1, 3, 282. 1–3, 6; Smith 1971: 26, Figs. 23 and 469; Wever 1969: 26). An X-ray taken in the previously mentioned examination reveals a clear gap between the ‘iron core’ and blade, which lends further weight to the view that the iron blade was replaced with a bronze one (Simpson & La Niece 2010: 98–99, Fig. 7). Even in an initial report on bronze swords with an ‘iron core’, it is stated that in an X-ray, ‘an empty space can be seen in the area where the hilt and blade join’ (Okahara et al. 2001: 33). However, it has been considered that ‘regarding the area where the hilt and blade are joined, it is impossible to make an accurate judgment on the joining process without undertaking a careful examination of these sections’ (ibid., 34). Thus, when it comes to evaluating the material, the same data can be interpreted in different ways depending on whether the iron part is seen as an iron core or the vestige of an iron tang. As long as there remain unsolved issues with regard to clarifying the iron core’s function and the aforementioned problems with bronze swords with an iron core, the “iron tang” theory (that the iron blade was replaced with a bronze one) will persist.

4. Modifications in the Bronze-Hilted Iron Swords and Future Challenges

(1) Iron Cores or Iron Tangs?

Whatever function was played by the iron component that is so central to this discussion, it is certain that the full-scale use of iron in the Middle East proliferated in the form of bimetals swords. There is no denying the intrinsic significance of the attempt to answer the question about the origins of bimetals swords and their production technology. The evolving discussion has been predicated on the existence of bronze swords with an iron core and, for those who proposed this idea, the existence of bronze-hilted iron swords. While there is no significant difference in form, the discrepancy in terms of one type being a bronze-hilted bronze sword (with an iron core) and the other being a bronze-hilted iron sword has led many to believe that the former was the prototype of the latter.

The tang theory proposed by Simpson and La Niece casts serious doubt on the very existence of the bronze sword with an iron core. If this theory were to become generally accepted to some degree, then the findings and theories that were based on the existence of the bronze sword with an iron core would have to be fundamentally reassessed. If it is true that extant bronze blades have been modified and then fitted into the hilt, then we must reassess the above-mentioned typological and chronological sequencing that had placed importance on the full length of the sword. The point about the structure’s fragility (being comprised of multiple components bonded together with soft solder) will also lose its value as grounds for arguing for the ceremonial function theory (Simpson & La Niece 2010: 100). The argument that the components traditionally considered as iron cores are in fact all that remain of tangs from the original iron blades after modification has meant that considering the bronze sword

with an iron core as a single typological class may itself be misleading.

However, the iron tang theory is based on specific and quantitatively limited material held in a single institution (the British Museum). It was not based on results of directly examining the group of materials that provided the basis for the iron core theory to become established. If the materials were purchased from a variety of different channels, then they may well have discrepancies in terms of their form and whether or not they were modified. Thus, without conducting separate re-examinations of different bronze swords with an 'iron core', it is premature to immediately accept the iron tang theory as the general one.

(2) Re-examining the Bronze Swords with an 'Iron Core' Held in Hiroshima University

Regarding the specimens held by Hiroshima University that are presented here, Kontani. (2001a) have pointed out that in many of the specimens, the iron rod is present all the way to the guard, and they have therefore been previously presented as bronze swords with an 'iron core'. In addition, most of the specimens (bronze-hilted iron swords 1–6) belong to the 'ear pommel sword' typological class, which was central to the typological and chronological sequencing of bronze swords with an 'iron core'. The data that can be gained from these specimens can therefore contribute significantly to the discussion described above. We will now summarise the findings collected from the specimens held by Hiroshima University in conjunction with a general overview of the current research situation.

First, it has been clarified that the iron rod branches out in two directions along each flank of the U-shaped or V-shaped guard. This finding resulted from the process of verifying the internal structure, which involved close examinations with the naked eye and a magnet, and a gamma ray irradiation scan, which was carried out with Professor Shizuma. The probability of the finding (fork in the rod) being accurate was considered high. The forked iron rod has not previously been identified as a feature of bronze swords with an 'iron core', nor has it been referred to by advocates of the theory that the 'iron core' had a specific function. Why then does the iron core fork into branches forming a Y- or T-shape? We thus have another finding that cannot be dismissed by the existing bronze sword with an 'iron core' hypothesis.

Moreover, the research also confirmed that the sword components had been bonded together by a soft solder, and that an oil-based paint was brushed over the soft solder and putty. Such a discovery has provided a critical piece of evidence to the iron tang theory advocated by Simpson and La Niece as a rebuttal against Kontani. We could never accept these as production features that emerged in the Middle East in the 2nd millennium BC. On the other hand, it seems perfectly reasonable to speculate that the Y-shaped intersection of the iron rod embedded in the guard is in fact the remnant of the blade's original part. We therefore believe that the results of the examination support the view advocated by Simpson and La Niece that iron blades were replaced with bronze blades. This is why we have explained in detail how the specimens held by Hiroshima University which had been considered as bronze swords with an 'iron core' are in fact very likely to be bronze-hilted iron swords

that had their iron blades removed and were then refitted with bronze blades.

If we consider the tang theory, the intention behind the modification is clear (Figure 11). Modern techniques were used to remove the corroded blade and replace it with a more aesthetically valuable bronze blade, so that the swords would fetch a higher price on the antiques market. A study of Bronze-Hilted Iron Swords 2, 5, 6, and 7, etc., reveals that since the retrofitted blades were originally wider than apertures of the guards into which they were slotted, their width was reduced by whetting down or beating, hammering the blade edges so that the blade would fit. Since these blades are narrower toward the tip, it would have been possible to accomplish this feat by cutting off the blade's wider part towards the base, leaving only the narrower section of the blade. Why then was this method not adopted? It is simple enough to suppose that the former method was used in favour of the latter because it was believed that longer swords would fetch higher prices. Therefore, if a sword had a large aperture after its original iron blade was removed, a longer bronze blade would likely have been fitted in and then bonded with a soft solder. A good example of this is Bronze-Hilted Iron Sword 2, which has a magnetic sphere ending around the right-angled joint. The area of aperture into which the bronze blade was fitted is very large, which is probably why there appears to be only a small amount of soft solder joining the two components. In any case, even the lengths of the blades are different from the original in such specimens.

Furthermore, it is impossible to claim that the bronze blades used in the modification work were all excavated materials. In this respect, we differ from Simpson and La Niece (*ibid.*, 100). What has been clarified by the radiographs (X-ray and γ -ray) conducted in the Research Centre of the Hiroshima University Graduate School of Engineering is that in this group of materials (Bronze-Hilted Iron Swords 2–8), the bronze blades have no pores at all. On the other hand, all the respective guards, grips and pommels are riddled with pores. These pores are probably the development of tiny apertures resulting from casting defects such as air pockets and misruns. If the bronze blades underwent the

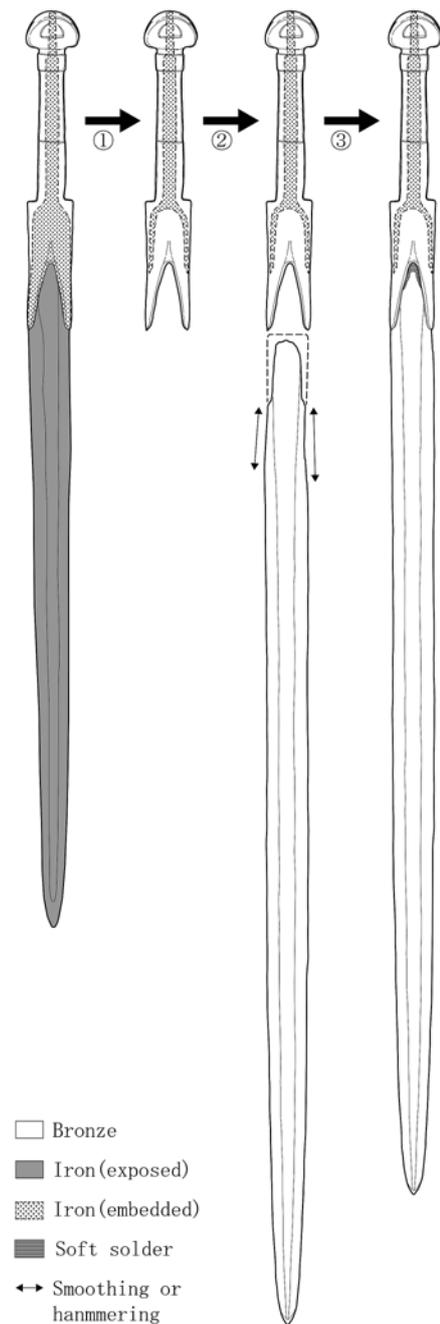


Figure 11. Production methods for bronze swords with an 'iron core'

same chemical changes as these other bronze components, then they should have the same degree of porosity, yet the results show that the bronze blades are not porous at all. From this finding, we conclude that we cannot dismiss the possibility that the bronze blades themselves may have been cast in modern times. We must also entertain the possibility that even the linear incisions engraved on the guards, grips and pommels may also have been added by a later generation in order to cover traces of modification.

According to a chemical analysis of the iron tangs (conducted on the bronze-hilted long swords held at the Okayama Orient Museum [Bronze 84–440])⁽⁶⁾, they have an estimated carbon content of 0.25–0.35%, and are assumed to have been forged using a mixture of ferrite and fine-grained pearlite (Okahara et al. 2001: 35). To elaborate on this analysis, the iron tang components contain only very low amounts of carbon, suggesting that they were wrought iron. If the iron rods were in fact originally inside long swords, it is likely from a functional point of view that the blades were made from carbon steel, which would be even harder than the tangs. If the smiths had actually perfected such a manufacturing process for iron blades, this would suggest that they had succeeded in controlling the levels of carbon for forging iron. Of course, it is also possible that the smiths may have understood such techniques as forge welding (welding the blade and tang together in a ‘molten’ state). Particularly in the case of a specimen like Bronze-Hilted Iron Sword 1, it is definitely possible that the tang and blade may have been welded together. It is also possible to speculate that the technological base for producing cutting tools--i.e. the ability to deoxidise raw iron material such as iron ore in a solid state, refine the material and control the carbon levels--may have already been established at this point. Such a manufacturing technique is markedly different from the assumed processing technique that involved a forged iron core being inserted with soft steel. In order to verify this in detail, chemical analyses on the iron blades themselves are needed. This is a matter of some urgency, as these iron blades are not circulating on the antiques market and they are gradually being lost, one after the other.

(3) Toward Research that Reconstructs the Manufacturing Techniques

The fundamental question concerning the materials discussed in this paper--iron cores or iron tangs?--remains unresolved, so it is arguably premature to talk about the manufacturing techniques. However, if we cannot speculate about the manufacturing process of these materials, then we have no reference point for understanding the ways to verify modern modifications. Conversely, if we do not examine the extent of modern modifications and clarify the repair techniques as observed in the modification traces, then it will prove extremely difficult to reconstruct the original manufacturing techniques. Thus, when it comes to reconstructing the manufacturing techniques of these materials, speculation on the original techniques and clarification of modern modifications are closely connected.

According to the iron tang theory, the area of the sword from the tang to the connecting part is fixed in the mold and then molten bronze was poured in. It is noteworthy that since the tang tip can be seen

running continuously to the front surface of the pommel in many typological examples, it may be that the tip was set face down vertically into the cylindrical mold used for the grip and then molten bronze was poured in. If this is the case, then it would be possible to fix the tang tip onto the base of the mold used for the pommel and then carefully maintain its central and vertical position. As for the grip, there would be no need to use a bivalve mold and hold the outer shell and inner core in place. The smiths probably just used a cylindrical mold with a circular opening. Given that there are no mold lines such as casting fins along the grip, it is unlikely that a double mold was used. It would still be possible to firmly argue that the engravings were made after the casting. However, we must assume a more complicated mold structure for the pommel. In many cases, the guard, grip and pommel are slightly off-centre from each other. It is reasonable to assume that the molds for each component were stacked vertically, followed by the pouring of molten bronze.

On the other hand, if we are to reconstruct the manufacturing techniques, it is also essential to re-examine the purchased material upon which the iron core theory was based, while keeping in mind the iron tang theory. We need to gain an accurate understanding of the embedded iron based on a reconfirmation of the sphere of magnetisation and data on accurate radiographs and cross-sectional form. Another necessary task is to gather material data that has a clear origin. In short, we should return to what is considered the fundamental analytical process of archaeology. Unfortunately, the reality remains unchanged: the number of excavated examples of relevant material is still not enough for an adequate analytical sample. If there is no hope of additional excavated examples, we are forced to continue relying on purchased materials. Any re-examination of them will therefore need to be especially strict.

5. Final Thoughts

One of the reasons for writing this paper is that the bronze-hilted iron swords held by Hiroshima University have been presented as materials supporting the iron core theory, in spite of the fact that a fully detailed description of them has not been published (Kontani 2005: 399–400; Simpson & La Niece 2010: 99).

So far, the iron core theory supporters have not responded to the iron tang supporters. If we are to proceed believing the iron core theory, then we need to use direct observations and material analysis to verify whether or not there were any modifications added later. At the same time, it will be necessary to, at the very least, demonstrate empirically that the extant ‘iron cores’ which the iron core supporters have thus far relied on could not possibly be iron tangs. Having done this, it will be necessary to present a more probable explanation as to why iron cores were embedded in these swords.

On the other hand, if we are to take the position that the iron rods are definitely iron tangs rather than iron cores as was previously thought, and that the bronze swords with an iron core that existed in the mountain range next to the Caspian Sea at the end of the 2nd millennium BC are in fact nothing

other than bronze-hilted iron swords, then we must accept that the technology during this period was already at a level capable of producing ironware. Moreover, it would mean that a more primitive use of iron likely existed before this time. As discussed above, it is very possible that the smith technology by which these tools were produced was at a level that could control carbon levels and fashion iron into tools. We may even be able to identify the actual time from which the use of ironware began. It is no exaggeration to say that this could potentially overturn the Hittite monogenesis theory.

The report in Japan of the ‘discovery’ of bronze swords with an iron core concluded with the following sentiments. ‘When making this report, there were some who questioned the authenticity of the specimens’ value as works of art. (...) I questioned to myself whether I should play it safe and leave them be as art objects and remain in doubt, or whether I should consult the opinions of a wide range of scholars around the world, despite the problems involved in doing so. In the end, I opted for the latter’ (Kontani 2001a: 26). In this paper, we have presented these materials from the perspective of the iron tang theory. However, we hope that this study will inspire further analysis of the existing materials. If such analysis produces new findings, or if the findings refute our hypothesis, we would welcome them as an unexpected delight.

Please note that the materials presented here are based on observations, measurements and photographic images that were made in the course of practical training sessions for handling material in the Hiroshima University Graduate School in 2013. These observations, measurements and photographs of the bronze-hilted iron swords were conducted by graduate students Masahiro Fujii, Susumu Murata, Hakuhiro Ichikawa, Shohei Fujii and Naoto Morimoto, who participated in the practical training under the guidance of professor Nojima and special researcher of the Japan society for promotion of science, Arimatsu. These students took charge of surveying the materials and writing up the results⁽⁷⁾. In addition, the ‘Introduction’ was written by Nojima, ‘Overview Research on Bronze-Hilted Iron Swords from Western Asia’ by Arimatsu and ‘Modifications in the Bronze-Hilted Iron Swords and Future Challenges’ and ‘Final Thoughts’ were created under the discussion of Nojima and Arimatsu. Professor Nojima edited the paper, and both made the final adjustments.

To conclude, we would like to express our appreciation for the generous guidance and support provided to us in presenting these materials. We would like to thank Professor Emeritus Kiyohide Furuse of the Hiroshima University Graduate School of Letters for giving us permission to publicise the materials. We would like to thank Professor Kiyoshi Shizuma of the Hiroshima University Graduate School of Engineering for taking various radiographs of the bronze-hilted iron swords presented in this paper, and also for making painstaking efforts to produce clear images showing the internal state of the materials and the whereabouts of the embedded iron. We would also like to thank Ryuji Shikaku, Chief Curator of the Okayama Orient Museum, for giving us permission to survey the articles held in the museum, and for his many suggestions. Let us not forget Chikako Takaoka, Curator of the Ohara Museum of Art (PIIF), who accommodated our request to survey the material

held there. We would finally like to thank all the institutions and individuals listed below.

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Notes

- (1) The bronze-hilted iron sword specimens presented in this paper correspond to the following: Bronze-Hilted Iron Sword 1 (Hiroshima University Archaeological Research in Iran, 1973, 43a. Long Sword with Iron Blade and Bronze Hilt), Bronze-Hilted Iron Sword 2 (ibid., 44. Long Sword with Bronze Hilt), Bronze-Hilted Iron Sword 3 (ibid., 46a. Long Sword with Bronze Hilt), Bronze-Hilted Iron Sword 4 (ibid., 46b. Long Sword with Bronze Hilt), Bronze-Hilted Iron Sword 5 (ibid., 45. Long Sword with Bronze Hilt), Bronze-Hilted Iron Sword 6 (ibid. 1973, 43b. Long Sword with Bronze Hilt), Bronze-Hilted Iron Sword 7 (ibid., 43c. Long Sword with Bronze Hilt) and Bronze-Hilted Iron Sword 8 (ibid., 47b. Long Sword with Bronze Hilt).
- (2) The X-ray that appears among the radiographs shown in Illustration 3 is an image taken by Kazuo Miyazaki of Kansai X-Ray Co., Ltd., located in Minami-Kannon, Nishi-ku, Hiroshima (RF200EGS2, February 10, 1988). We would like to thank Professor Kiyohide Furuse for allowing its publication. As for the γ -radiographs, they are images taken by Shizuma Research Group of the Energy Engineering Program of the Hiroshima University Graduate School of Engineering.
- (3) Reagent grade acetone, Cat. No. 01026–00 (special grade JIS K8034), Kanto Chemical Co., Ltd.
- (4) According to the X-ray fluorescence analysis conducted by Professor Shizuma's group, the solvent consisted of a mixture of tin and lead.
- (5) For more information on the excavated examples of bronze-hilted iron swords in these regions, please refer to the following literature: Fukui & Ikeda (eds.) 1971: Figs. 27. 4, 44. 1; De Morgan 1925: Fig. 251. 2–4; Gambaschdze et al. 2001: 406; Khalatbari 2004: Figs. 50–53; Maxwell-Hyslop 1946: Pl. 39. 2; Schaeffer 1948: Figs. 232. 1, 3, 4, 11–12, 237. 16, 271. 1, 3, 282. 1–3, 6; Smith 1971: 26, Figs. 23 and 469; Wever 1969: 26.
- (6) In fact, a magnetic examination of the bronze-hilted long swords held at the Okayama Orient Museum [Bronze 84–440] confirmed that the iron rod forks in the guard to form a T-shape. This finding is regarded as evidence that these swords may also be bronze-hilted iron swords.
- (7) The various observations and recordings were undertaken by the following individuals: Bronze-Hilted Iron Sword 1: Naoto Morimoto; Bronze-Hilted Iron Sword 2 and Bronze-Hilted Iron Sword 8: Susumu Murata; Bronze-Hilted Iron Sword 3: Masahiro Fujii; Bronze-Hilted Iron Sword 4: Hakuhiro Ichikawa; Bronze-Hilted Iron Sword 5: Shohei Fujii; Bronze-Hilted Iron Sword 6: Hisashi Nojima; Bronze-Hilted Iron Sword 7: Yui Arimatsu.

広島大学考古学研究室所蔵の西アジア青銅柄鉄剣をめぐって

野島 永・有松 唯・藤井雅大・村田 晋・
市川伯博・藤井翔平・森本直人

いわゆる「鉄芯」入り青銅剣（バイメタル青銅剣）とされてきた広島大学考古学研究室所蔵資料についての再調査を行う。バイメタル青銅剣は、紀元前800～1200ごろ年にカスピ海南部の山岳地帯において出現する金属器で、鉄利用の初期の様相を明らかにするうえで重要である。西アジア北部地域における鉄製利器の祖型として、鉄製棒状部品を内蔵する青銅剣（「鉄芯」入り青銅剣）の存在が指摘され、編年・機能研究が行われてきた。しかし、当該資料はおそらく現代において改変された青銅柄鉄剣であったことが判明した。他機関所蔵品の知見も加味すると、研究対象の多くに同様の可能性があり、「鉄芯入り」青銅剣を前提に導かれたこれまでの知見や議論は根本的な見直しを迫られることになる。紀元前2000年紀の終わりにカスピ海周辺に出現する「鉄芯入り」青銅剣が実は青銅柄鉄剣であったわけであり、それ以前に鉄製利器の導入期といった、より原初的な初期鉄器の実態がある可能性が高くなる。今回の再調査はそうした研究の脆弱性を露呈し、西アジアにおける初期鉄器時代の議論を転換する結果となった。

Colour Illustration 1



(1) All the bronze-hilted iron swords shown together



(2) All the bronze-hilted iron swords shown together (closeup of the grip)

Colour Illustration 2



Detection of soft solder/putty



Image 1. Full view of Bronze-Hilted Iron Sword 1



Image 2. Full view of Bronze-Hilted Iron Sword 2

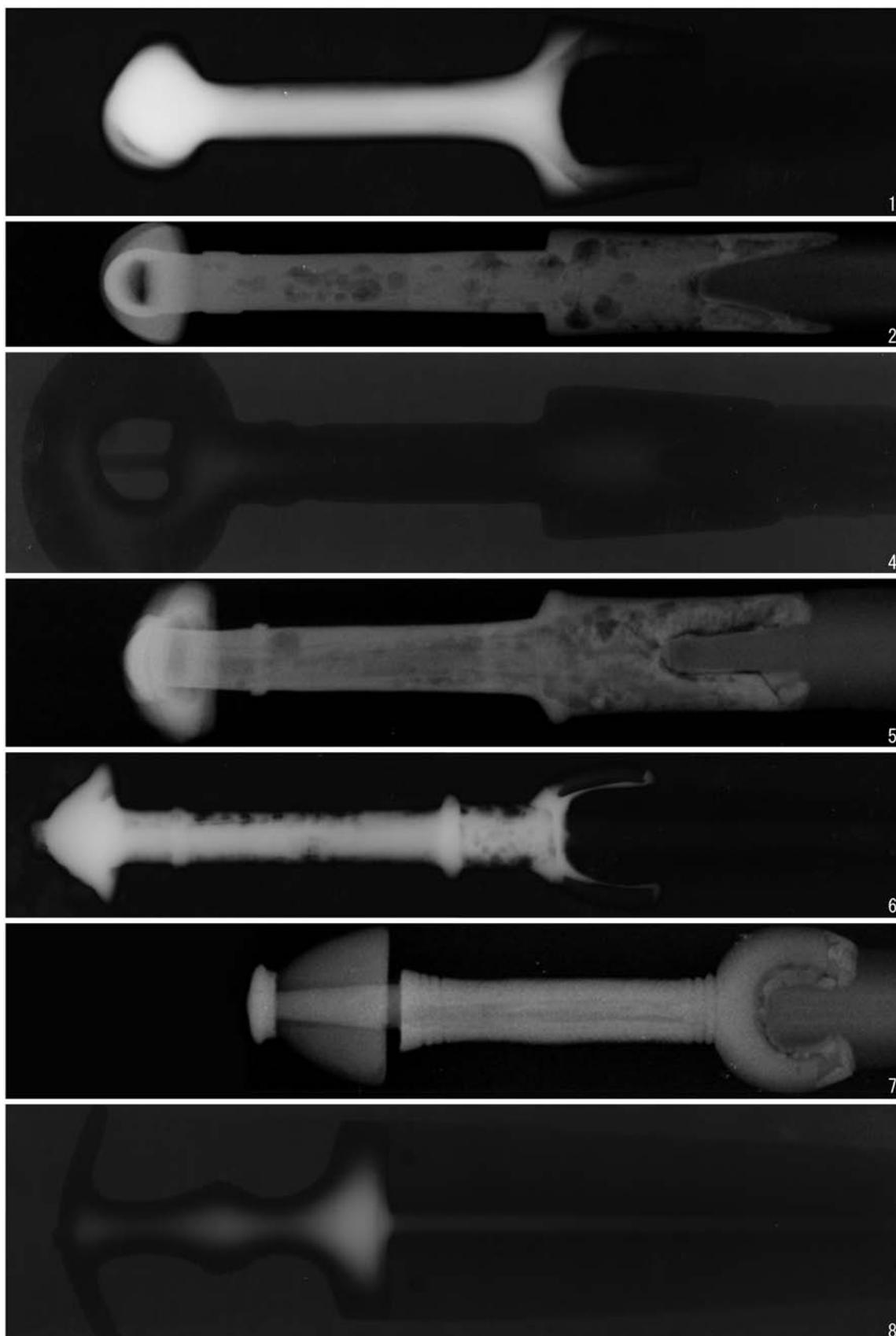


Image 3. Bronze-hilted iron sword radiographs
(1, 4, 6 and 8 are X-rays and 2, 5 and 7 are γ -radiographs)