# The true and the fake: archaeometric investigations on two Bronze Age solid-hilted swords from East Flanders (Belgium)

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## 1. Introduction

Bronze Age solid-hilted swords are particularly uncommon in Belgium (Dumont 2019). Four are currently known: one was found in Belgium without any further precisions (Warmenbol 1984, 134), one hilt fragment comes from the Trou del Leuve un Sinsin (prov. Namur; Warmenbol 1984) and two were discovered in East Flanders, in the surroundings of Ghent (Maertens de Noordhout 1936; Desittere 1974, 147-148; Verleackt 1996, 123) and in Asper (Gavere; Hasse 1940; Verlaeckt 1996, 86).

This article focuses on the two East Flemish swords that were recently studied. In addition to a careful macroscopic examination, they were also analysed in Ghent University. Radiographs enabled a reconstruction of their production process and the elemental composition of their different parts was analysed by X-ray fluorescence spectroscopy. These analyses allow us to answer the delicate question of their authenticity, which was discussed at several occasions in the past and about which there is no consensus.

## 2. Methods

### *2.1. Digital radiography*

2D X-ray projections were acquired using HECTOR, a micro-CT scanner at the Centre for X-ray Tomography of the Ghent University (www.ugct.ugent.be). HECTOR is a high-energy micro-CT scanner (Masschaele *et al.*, 2013), which is suitable for both larger samples and samples with a high X-ray attenuation which is the case for these bronze artefacts. The X-ray source is an X-RAY WorX XWT 240-SE microfocus source, which is operated at 200 kV and 50 W for these experiments. The source was equipped with a 1 mm Cu to filter low energy X-rays. Images were acquired with a PerkinElmer 1620 CN3 CS flat panel detector where the 2024 x 2024 0.2 mm pixel range was cropped to fit the sword projection. Projections were acquired over different vertical steps to cover the length of the sword. The images were averaged over 100 normalised images, each with 1 s acquisition time.

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### *2.2. X-Ray fluorescence*

When exposed to X-rays, atoms can produce a secondary X-ray emission called fluorescence. Each element produces an emission with characteristic wavelength or energy. X-ray fluorescence (XRF) analysis consist in analysing the emission of a sample when exposed to X-rays to determine its elemental composition. The main advantage of this non-destructive technique is that it can be executed directly on the object using a hand-held device, making it a totally non-invasive technique.

XRF analyses on Bronze Age swords were conducted by Ghent University departments of archaeology and chemistry with an Olympus Innov X Delta Premium commercial instrument coupled with a rhodium (Rh) based X-ray tube and a silicon drift detector (SDD). An aluminium (Al) filter was applied for measuring the higher Z-elements (from Al onwards), as well as a tube voltage of 40 kV and a current of 38.7 µA. The measurements were performed in air for 300 s (live time) with the Geochem mode of the instrument. All measurements were performed using a polychromatic X-ray beam for excitation (5 x 5 mm²). The collected spectral data were processed using the dedicated XRF spectrum evaluation software AXIL "Analysis of X-ray spectra by Iterative Least squares" software packages. As the different peaks on these spectra correspond to the x-ray emission of the elements composing the metal, it is possible to perform a qualitative analysis. Quantification of the different elements would require a calibration using suitable reference materials. XRF spectroscopy also presents drawbacks: XRF measures the composition on the surface of the object (~200 µm, depending on the sample matrix and excitation energy) and is as such affected by its surface state. The corrosion is known to affect the distribution of the elements and especially to reduce the proportion of copper (Wrøbel Norgaard 2017, 103), which might not be representative of the original alloy.

## 3. The solid-hilted swords from Ghent surroundings

### *3.1. Presentation*

The sword from Ghent vicinity (fig. 1) firstly belonged to Albert Cels, a painter and collector from Brussels. It was sold in 1933 and bought by M. Maertens de Noordhout (1936). It is now conserved in Ghent city Museum (STAM) under the inventory number 9801. This 62.5 cm long sword weighs 840 g and consists of a 10.0 cm long hilt formed of a circular pommel in the shape of a shallow cup with a diameter of

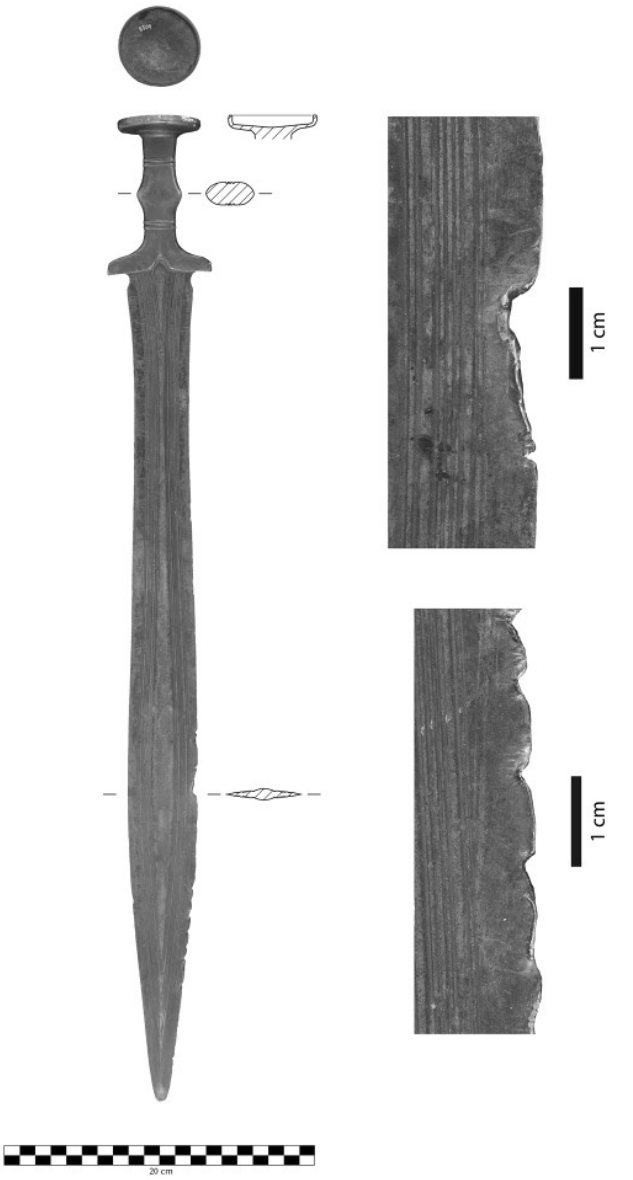


*Fig. 1. Overview the sword said to come from the vicinity of Ghent (STAM, 9801) and details of the damages on the blade. Pictures: L. Dumont.*

5.4 cm, a grip with a central bulge decorated with a circle pattern and framed with two groups of ribs, a 6.7 cm wide wing-shaped guard with a small central notch and finally a 52.5 cm long leaf-shaped blade decorated with several groves and presenting a few damages located in the bottom third. A homogeneous golden brown patina covers it.

The Ghent sword was first published as an authentic sword showing parallels with southern Germany (Maertens de Noordhout 1936; Desittere 1974) before E. Warmenbol questioned its exact nature (1984, 135). The lack of information about its discovery and the catalogue of the Cels collection sale being the only indication concerning the provenance of this object, it can indeed be considered as a suspicious element. The radiography M. Desittere wanted to realise (1975, 122) never happened (Verlaeckt 1996, 123), until now.

Although there is no information about the context this sword comes from and the unusual shape of the pommel, it can be dated to the very end of Late Bronze Age (9th century BC; Bronze final IIIb or Ha B2/3) thanks to its very typical wing-shaped guard, which finds parallels in many types from this period (Mörigen, Auvernier, Tachlovice, Weltenburg etc.).

### *3.2. Inner structure and composition*

The X-ray examination of the hilt area (fig. 2) performed at Ghent University Centre for X-Ray Tomography reveals the incredibly homogeneous structure of the bronze composing the object. This is literally a perfect casting, that does not present any kind of porosity linked to gas trapped in the metal during the casting or to elements such as coal or clay that could have been mixed to the bronze when it was poured in the mould. There is also a clear continuity between the hilt and the blade indicating that the two parts were clearly cast together as a single object.

The spectra resulting of the XRF analysis (fig. 2) are consistent with an object cast in one piece: the composition spectra lf the hilt and the blade almost perfectly overlay one another, with no significant difference. A peak on the spectra indicates the presence of zinc in the alloy, which can be considered as suspicious for a Bronze Age object.

### *3.3. Interpretation and discussion*

Swords whose hilt and blade are cast together are very uncommon in the Bronze Age. If many swords were considered being made this way in the past, the outbreak of X-ray applications in archaeology since the 1950s show that these sword usually present an over-cast hilt, which is cast directly over the blade, leaving no fixation trace such as rivets. Approximately 1570 solid-hilted swords are currently known in Late Bronze Age Europe. Among them, 380 were x-rayed and only 4 appear to be cast in one piece, mostly coming from eastern Europe and belonging the the Prejmer type imitating Central Europe *Dreiwulstschwerter* (Bader 1991, p. 135-137; Quillfeldt 1995, p. 183-184).

The stunning homogeneity of the casting is also uncommon, not to say unique. So far, all genuine x-rayed swords from the Bronze Age presents defects, mostly consisting in porosity resulting from the casting process.

Finally, Bronze Age objects with a high zinc level (e. g. > 5%) are usually discarded from scientific studies (Schwab *et al*. 2010, 8). Zinc is indeed not known in the Bronze Age and objects made with this metal can be considered as fakes or replicas. In the case of Ghent sword, a quantification of the zinc level in the metal should be performed using suitable reference material to get a precise idea of the percentage of this element in the alloy. In the analysis made on east German swords, the normal zinc concentration does not exceed 0.022% (Wüstemann 2004, 260).

At this point, the odd production process and the composition of the Ghent sword make it a suspicious object, which is likely to be a fake or a replica of a genuine Bronze Age swords. Similar swords were found in the Musée des Anti-

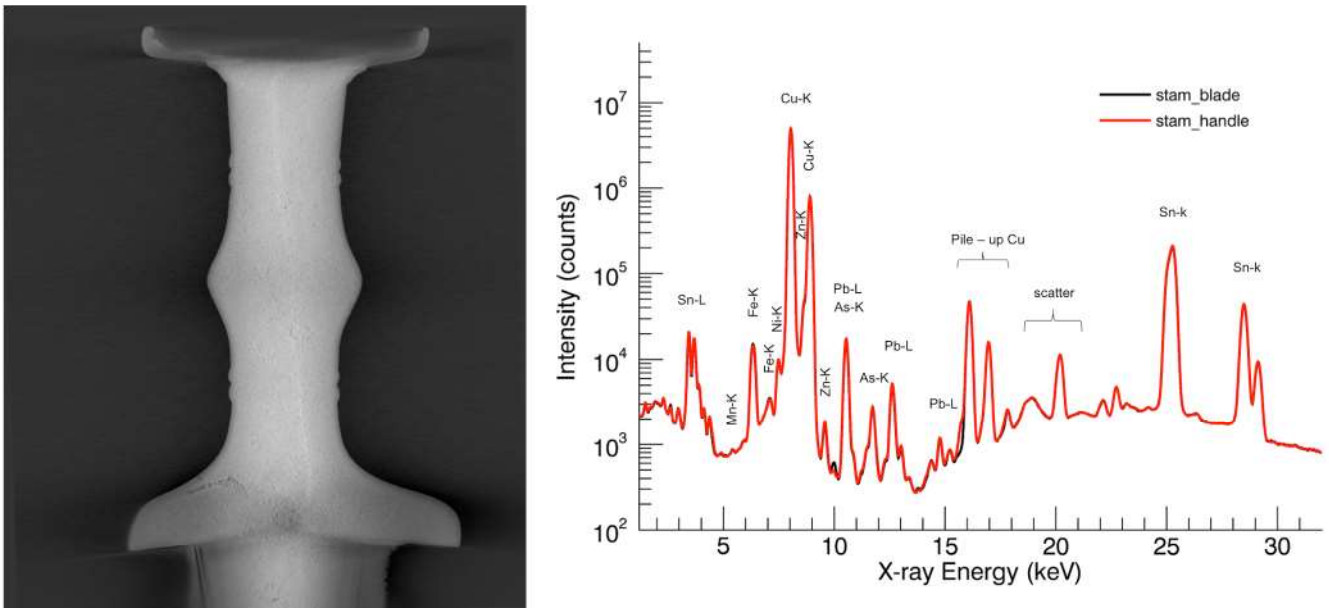


*Fig. 2. Coronal setion of the hilt area (picture: T. De Kock) and XRF spectra of the hilt and the blade indicating the different elements composing the alloy (XRF analysis : S. Lycke and P. Tack).*


*Fig. 3. Comparison between the original Bruck sword (Bavaria) and two of its replicas. 1. Bruck (Landshut Museum, nr A 606; Müller-Karpe 1961, pl. 87, 1). 2. Ghent, STAM, nr 9801 (picture: L. Dumont). 3. Saint-Germain-en-Laye, Musée d'Archéologie Nationale, nr 24967 (picture: L. Dumont).*

quités Nationales in Saint-Germain-en-Laye (fig. 3, 3) and in the Rijksmuseum van Oudheden in Leiden (nr. M 1922/11.4). However, contrary to the one conserved in the STAM, these objects are not corroded and do not present any use-wear traces. They are clearly copies. Archive documents in Saint-Germain-en-Laye reveal that these three swords are actually reproductions crafted by the Römisch-Germanisches Zentralmuseum in Mainz from the Bruck sword (Bavaria; fig. 3, 1; Quillfeldt 1995, 213), conserved in Landshut Museum (nr. A 606). Many copies of archaeological artefacts were and are still made in Mainz. They used to be very popular among European museums and many of them bought copies of emblematic artefacts. In this case, it is probable that a copy of the Bruck sword was bought from someone who realised a fake corrosion and fake damages on the blade so that the object really looks like an authentic Bronze Age sword. It was then sold as if it were with an invented provenance, giving it more value and more chance to find a buyer.

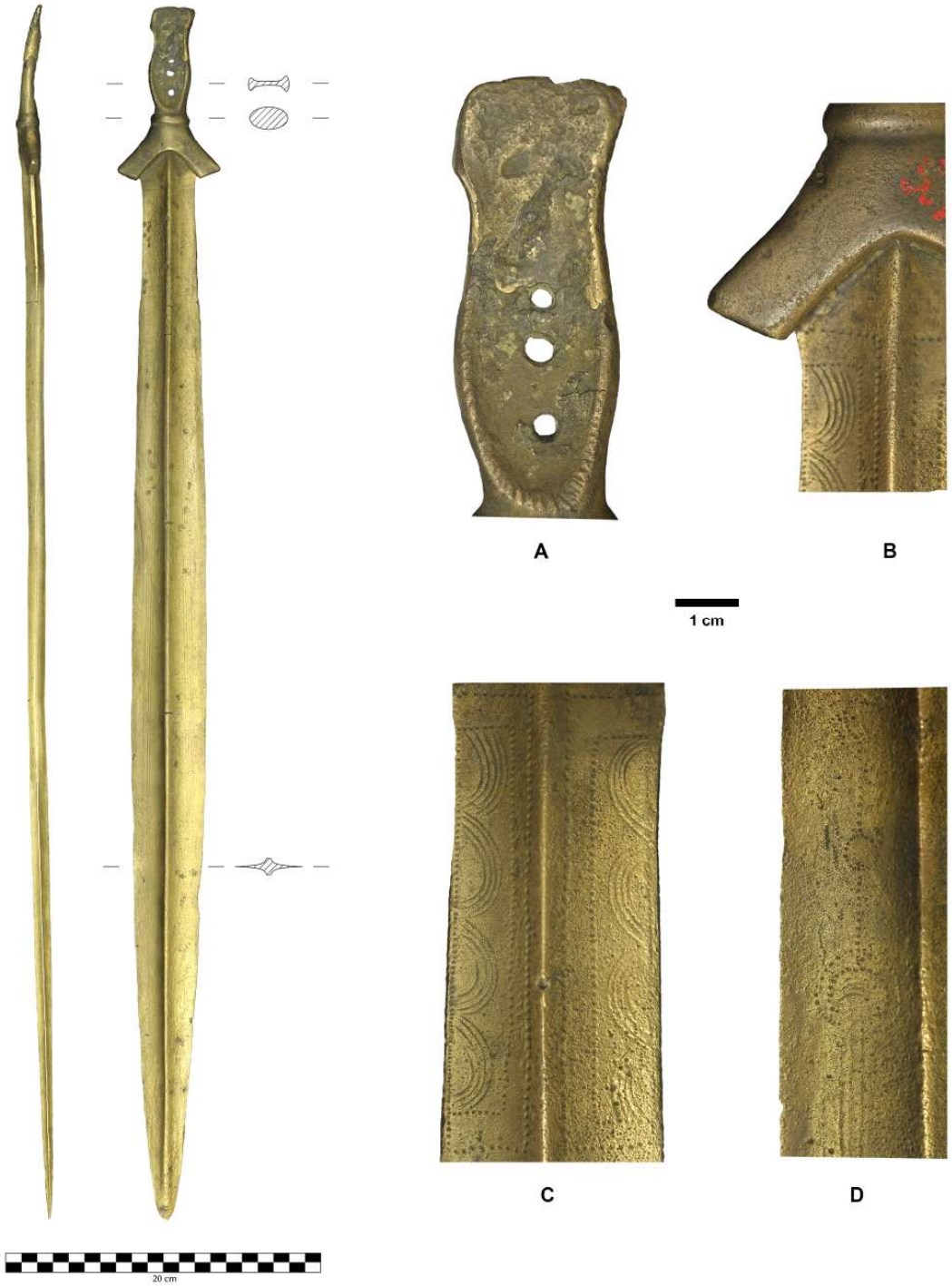


*Fig. 4. Overview of the Asper sword (MRAH/KMKG, nr PHN 581) and details of the hilt and the blade. Pictures: L. Dumont.*

As such, it is safe to conclude that the Ghent sword is a modern replica and should not be considered as a real archaeological artefact anymore.

## 4. The half full-hilted sword from Asper

### *4.1. Presentation*

The Asper sword (fig. 4) belonged to an ancient private collection from Oudenaarde and was acquired by the Antwerp archaeology museum (Vleeshuis) in 1940 (Hasse 1940). It is now conserved in the Art and History Royal Museums in Brussels under the inventory number PHN 581. It was probably found in the Scheldt river during the correction works, sometime between 1919 and 1922 (Verlaeckt 1996, 86).

This is a 77.0 cm long half bronze-hilted swords, meaning that the hilt consists of a tang in its upper part, which needed to be completed with riveted organic parts in wood or bone, and a solid bronze 6.2 cm wide V-shaped guard. The transition between the two parts is highlighted by a rib. Despite the eroded

surface of the metallic part of the hilt, an ornament composed of rows of half circles and dotted lines is still visible on one side (fig. 4, B). The side of the tang is also decorated with a cross frames in parallel lines. The 66.5 cm long leaf-shaped blade presents a prominent mid-rib, a *ricasso* (dull part at the top of the blade) and an unusually important ornamentation. Each side of the blade next to the *ricasso* is decorated with 4 patterns composed of 4 stacked half circles enclosed in a frame with 2 rows of dotted lines (fig. 4, C). Just before the grooves running from the second third of the blade to its tip are other ornaments consisting of three patterns placed on the top of each other and connected with a dotted line. The two upper patterns are simply formed with a dashed irregular oval shape. The bottom motif is more complex and is composed of two curved stippled lines forming two open oval shapes one into the other, at the centre of which is a pattern consisting of three stacked half circles (fig. 4, D).

The Asper sword was considered as a fake on the basis of the uncertainty of its context, its belonging to a private collection, the almost total absence of corrosion and unpublished metal analysis (Desittere 1972, 31). It was then rehabilitated as a trustworthy find considering the questionable reliability of the previously performed analysis (Verlaeckt 1996, 86). The study of its making and its composition enable us to settle this unsolved question.

### *4.2. Inner structure and composition*

The digital radiograph carried out in the Centre for X-Ray Tomography (fig. 5) allow us to identify 3 elements that compose the sword. Firstly, the blade presents a diffuse porosity scattered on all its length. The top of the blade is not easily recognisable as it is located below the metallic guard, but the tang sides can be identified as they consist of the interface between a porous and a more homogenous area. The upper limit of the tang is probably located under the bulge highlighting the transition between the metallic part of the hilt ant its upper part. The X-Ray examination also reveals that the bottom part of the blade's tang was equipped with two rivet holes that were filled when the hilt was casted. This hilt is itself composed of two elements. The solid guard and the first two thirds of the upper part, which consists of a tang to be completed with an organic lining, and the last third, which was cast on the tang. The transition between the two parts is visible on the surface of the hilt and the X-rays reveal that this cast part filled the fourth rivet hole, which is no longer visible.

In terms of composition (fig. 6), the spectra resulting of the XRF analysis indicate a very consistent copper (Cu) and tin (Sn) ratio between the blade and the bottom part of the hilt. There are however some differences considering other elements. The blade appears to contain less lead (Pb) but slightly more arsenic (As) and nickel (Ni).

### *4.3. Interpretation and discussion*

#### 4.3.1 Authenticity

Although the absence of corrosion may look suspicious, considering the results of the radiograph and the elemental analysis there is no reason to see the Asper sword as a fake or a replica. The porosity revealed by the X-rays inside the metal of the blade and the hilt is typical for Bronze Age castings and contrast with the perfection of the Bruck sword replica from the STAM (fig. 2). The almost total absence of zinc (Zn) in the blade and the hilt is also fully compatible with a Bronze Age copper alloy.

#### 4.3.2. Production

The radiograph also enables us to document the complicated production process of the Asper sword, which was made in

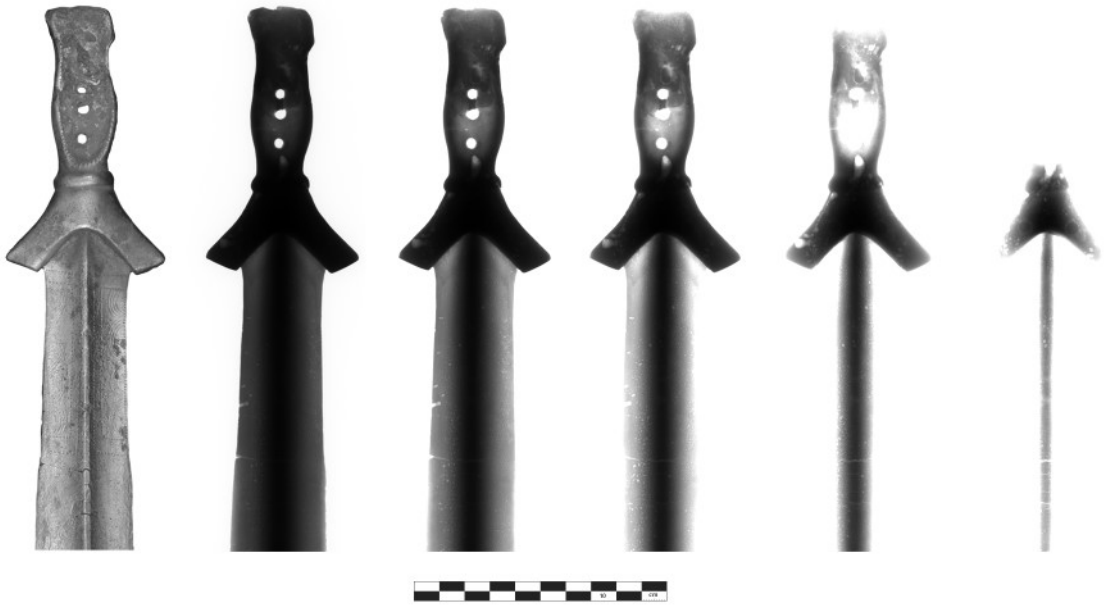

*Fig. 5. Radiographs of the Asper sword hilt area. Pictures: T. De Kock, L. Dumont.*

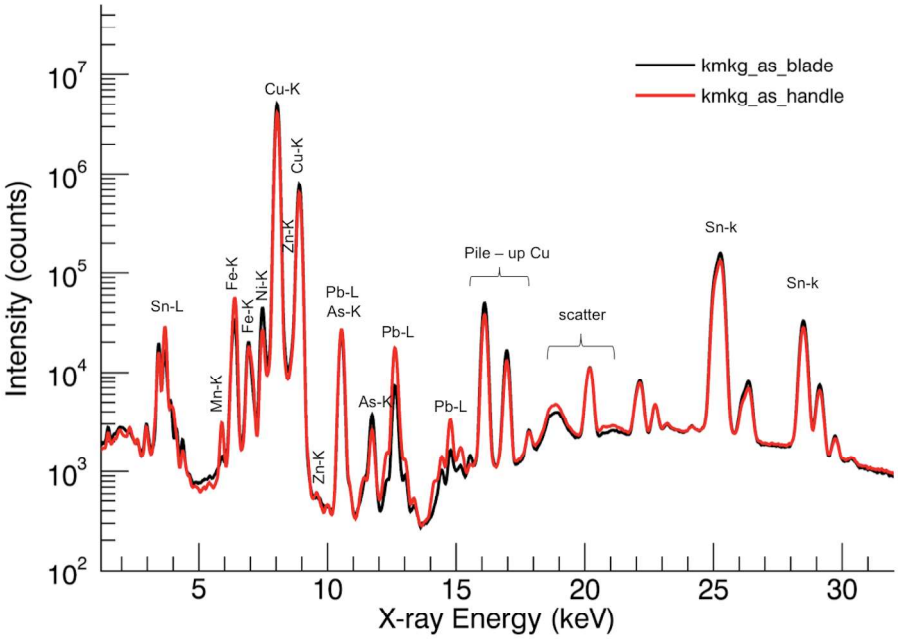


*Fig. 6. X-ray fluorescence spectra of the Asper sword's hilt and blade indicating the different element in the alloy (XRF analysis : S. Lycke and P. Tack).*

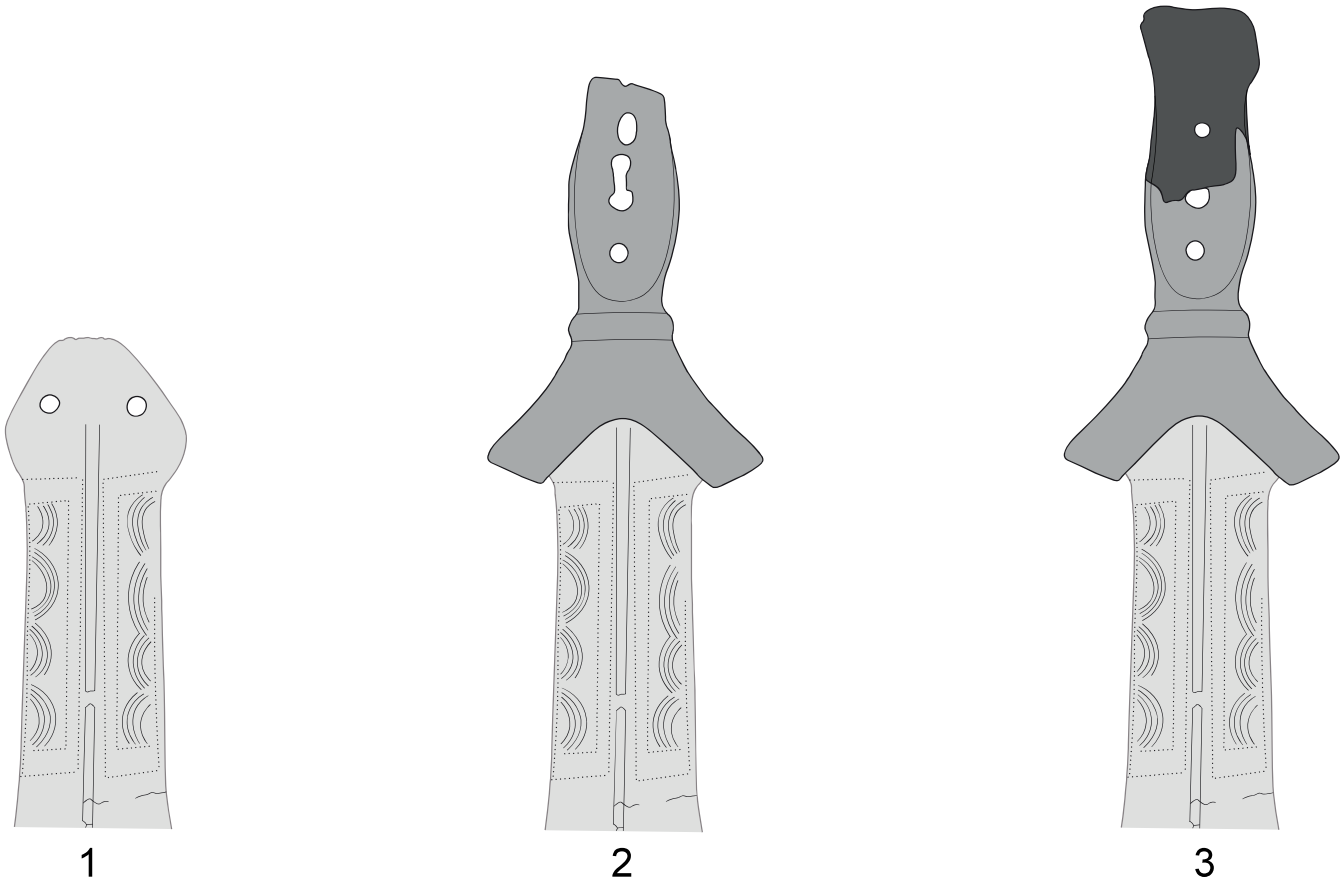


*Fig. 7. Reconstitution of the different steps of the Asper hilt production. CAD: L. Dumont.*

three steps. First of all, the blade was casted (fig. 7, 1). The presence of rivet holes indicates that it was probably designed to be originally equipped with an organic hilt riveted to the tang. It is likely that this tang broke just above the guard, which is the point where this part is getting narrower and thinner. This part was then reconstructed with a classic tang in the upper part and a solid bronze guard with a bulge at the transition between the two parts to ensure the solidity of the

hilt. Unfortunately, the casting of the tang was apparently not performed as it should have been and the top of it was miscast (fig. 7, 2), which lead a third casting on top of it to complete the hilt (fig. 7, 3).

It is difficult to say if this sword was ever used. The few traces on the blade seem modern and could have occurred when the weapon was found during work in the Scheldt river. It is possible that the rivets on the hilt were lost when the organic lining decayed, but we also cannot exclude the possibility that this sword was never completely finished and abandoned in the river without being ever used.

### 4.3.3. Dating and cultural parallels

Concerning the dating of the Asper sword, it finds very good parallels with Cowen's "late decorated swords" (Cowen 1955, fig. 14-15 p. 102-103), which are decorated with similar ornaments next to the *ricasso*. These types are dated to the end of Late Bronze Age (Ha B, 10th and 9th centuries BC; Jockenhövel 1997, 149-150). Concerning solid-hilted swords from this same period, we observe a contrast between the richly decorated swords from the 10th century BC and the much simpler ornaments of the swords dated back to the 9th century BC. The important decoration on the Asper sword's blade shall indicate a dating to the earlier phase (10th century BC).

As the original shape of this sword's tang remains unknown, which is the most distinctive typological feature of Bronze Age tang swords, a precise classification is impossible. However, the cross pattern on the side of the tang finds a few comparisons in Late Bronze Age tang swords, including several found in the Rhine valley, especially between the Neckar and Main confluences (fig. 8). This same pattern is also a very common ornament on the back of Late Bronze Age knife blades, in a very large area between the eastern Alps and the Rhine valley (Jiran 2002; Hohlbein 2016) with an important concentration in the Western Alps lake settlements, for example in Auvernier (Rychner 1979, pl. 108-113), Hauterive-Champréveyres (Rychner-Faraggi 1993, pl. 30-33) or the Bourget lake (Kerouanton 2002, fig. 22).

As there is no material proof of the workshops in which these decorated swords where produced, we will not make assumptions on the geographical origin of these weapons. However, the distribution of the swords and knives decorated with the cross and lines patterns shows that it had a certain success among populations located between the Western Alps lakes and the middle valley of the Rhine river. It is probable that the upper decorated part of the hilt was made by a craftsman and/or for a costumer who could have both been influenced by this Late Bronze Age trend, which only exceptionally reached North-Western Europe, where knives wearing this pattern remain very uncommon (Prüssing 1982; Warmenbol 1988; Butler *et al*. 2012). Although the absence of an identified production area for the Asper sword should make us cautious about its origin, it seems to bear punctual connections with the Rhine valley and possibly the Alps lake settlements.

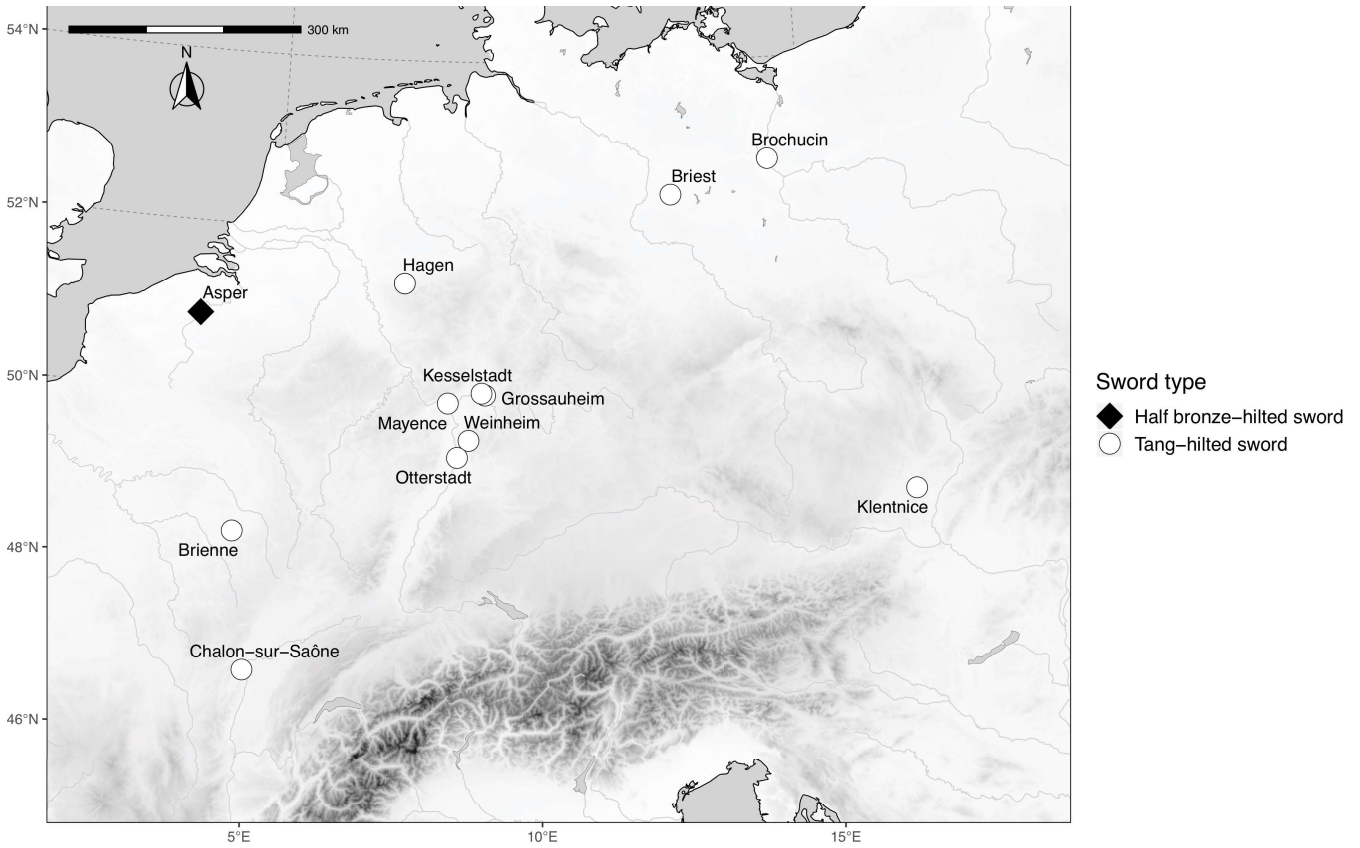


*Fig. 8. Distribution map of the swords decorated with similar lines and cross patterns on the side of their tang. Data: Sprockhoff 1931; Cowen 1955; Schauer 1971; Novak 1975; Bader 1991; Jockenhövel 1997; Wüstemann 2004.*

## 5. Conclusion

Radiographs and X-Ray fluorescence analysis performed on the two known Flemish bronze-hilted swords allow us to answer the delicate question of the authenticity of these artefacts, which was attempted at several occasions in the past. It appears that the sword conserved in the STAM and said to come from the vicinity of Ghent, despite its corrosion and the damages on its blade, is actually a replica of a Late Bronze Age sword from Bavaria produced by the Römisch-Germanisches-Museum in Mainz. The patina and the damages were possibly faked to make it look like a genuine sword. The Ghent provenance could have been invented to sell it more easily, even if it is not possible to know Albert Cels' role in this counterfeit.

On the opposite, the Asper sword, which may look suspicious due to its uncorroded and shiny surface, is a real Bronze Age sword. The radiograph shows that the original tang probably broke and was replaced by a semi-metallic hilt, which had to be completed by a third casting. Although some patterns on the blade are unique, the *ricasso* and tang decoration indicates possible connections with the middle Rhine valleys and the Western Alps lake settlements.

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