UNDER THE VOLCANO

Proceedings of the International Symposium
on the Metallurgy of the European Iron Age (SMEIA)
held in Mannheim, Germany, 20–22 April 2010

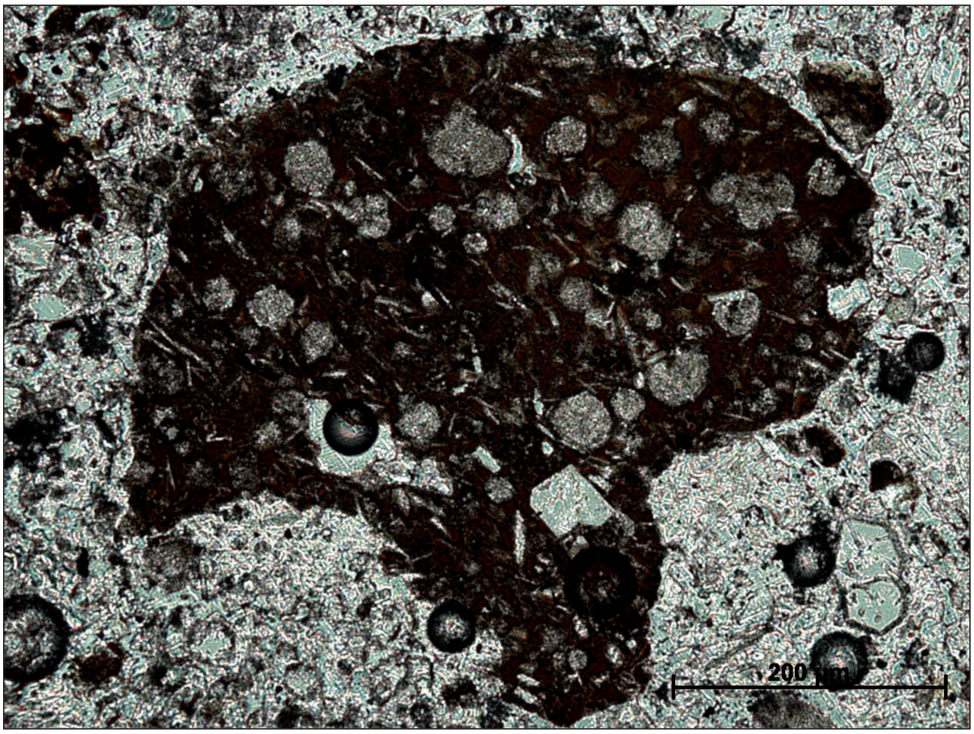
rem | Klaus-Tschira-Archäometrie-Zentrum
an der Universität Heidelberg

ein Institut der CEZ Archäometrie gGmbH

Forschungen zur Archäometrie und Altertumswissenschaft

herausgegeben von
Ernst Pernicka und Martin Bartelheim

Band 5



UNDER THE VOLCANO

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Edited by

Ernst Pernicka and Roland Schwab

Verlag Marie Leidorf GmbH · Rahden/Westf.
2014

220 Seiten mit 184 Abbildungen

Gedruckt mit Unterstützung der
Deutschen Forschungsgemeinschaft

Bibliographische Information der Deutschen Nationalbibliothek

Pernicka, Ernst / Schwab, Roland (Eds.):
Under the volcano ; Proceedings of the International Symposium on the Metallurgy of the European Iron Age (SMEIA) / hrsg. von Ernst Pernicka ...
Rahden/Westf.: Leidorf, 2014
(Forschungen zur Archäometrie und Altertumswissenschaft; Bd. 5)
ISBN 978-3-89646-875-8

Gedruckt auf alterungsbeständigem Papier

Die deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie.
Detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Verlag Marie Leidorf GmbH
Geschäftsführer: Dr. Bert Wiegel
Stellerloh 65 · D-32369 Rahden/Westf.

Tel: +49/(0)5771/9510-74
Fax: +49/(0)5771/9510-75
E-Mail: info@t-online.de
Internet: http://www.vml.de

ISBN 978-3-89646-875-8
ISSN 1610-5621

Umschlagentwurf: Sieghart Klentzke, Dresden und Martin Bartelheim, Tübingen
Satz, Scans, Bildbearbeitung, Layout und Redaktion: Daniel Berger und Roland Schwab, Mannheim

Frontispiece: Thin section of fall-out-lapilli-tuff from the eruption of Mount Vesuvius in AD 79,
The pyroclastic mixture originates from the interior of a gladiator helmet from Herculaneum (image: Roland Schwab)

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und Klaus-Tschira-Archäometrie-Zentrum an der Universität Heidelberg,
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Druck und Produktion: druckhaus köthen GmbH, Köthen

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CELTS AND ROMANS: A CONTRIBUTION TO RESEARCH INTO CULTURAL INTERACTIONS

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We examined a group of scabbards with elaborate copper-alloy (or, in rare cases, silver) openwork plates on the front and the associated swords from the transition of the Late La Tène to the Roman period. The study, including proton induced X-ray emission analysis (PIXE) and metallographic analyses, suggests that Roman craftsmen (and not Celtic, as was the hitherto prevailing view) manufactured them in the Celtic tradition, to accommodate Celtic tastes, but used material typical of Roman weapons (brass). Presumably they were intended for the elite of client (mostly Celtic) tribes and others who liked such weapons and to whom the Romans wanted to show favours.

KEYWORDS: BRASS, PRE-ROMAN, ROMAN, SCABBARDS, SWORDS, INTERCULTURAL RELATIONS, PIXE, SLOVENIA

INTRODUCTION

This article focuses on a group of scabbards and associated swords from the transition of the Late La Tène to the Roman period. Elaborate copper-alloy or, in rare cases, silver openwork plate on the front of the scabbard is the most distinctive feature of the group.

Our research was based on examination of four swords and their associated scabbards of the group from Slovenia, especially the one found in the River Ljubljanica near Bevke (Fig. 1 and 2.19). The other three are from graves (Strmec above Bela Cerkev near Šmarjeta and Verdun near Stopiče, graves 37 and 131; Fig. 2.20, 21; *cf.* Istenič 2010, figs. 1, 4–6, 8, 10, 13).

ARCHAEOLOGICAL CONTEXT

In-depth examination of the scabbards with elaborate non-ferrous openwork plates and the associated swords from Slovenia and other regions (Istenič 2010) showed that they make up a homogenous group of weapons, which, according to the information available, comprise at least 34 examples. They come from graves and, in two cases, from rivers. No known examples come from settlements. They were in use between 40/30 and 15 BC and perhaps also earlier, but not before about 60 BC, when the Romans introduced the use of brass to Europe.

Most of the scabbards under discussion were found between Luxembourg in the west and eastern Poland and Slovakia in the east, and between northern Poland in the north and Slovenia in the south (Fig. 2). The distribution of find-spots of the scabbards suggests they were used in the areas inhabited by Celtic and Germanic tribes but one or two examples come from the Thracian area. Distinctly high concentrations (five examples) appear in the wider area of the Moselle, which was inhabited by the *Treveri*, and in the territory of central and southern Slovenia, inhabited by the Taurisci; also notable are the find-spots in present-day Poland once populated by Germanic tribes (Istenič 2010, 141–142, fig. 13).

Fig. 1 *The sword from the river Ljubljanica in its scabbard; left – the front; right – the back; length is 75.3 cm, width 4.9 cm (photos: T. Lauko, Narodni Muzej Slovenije).*

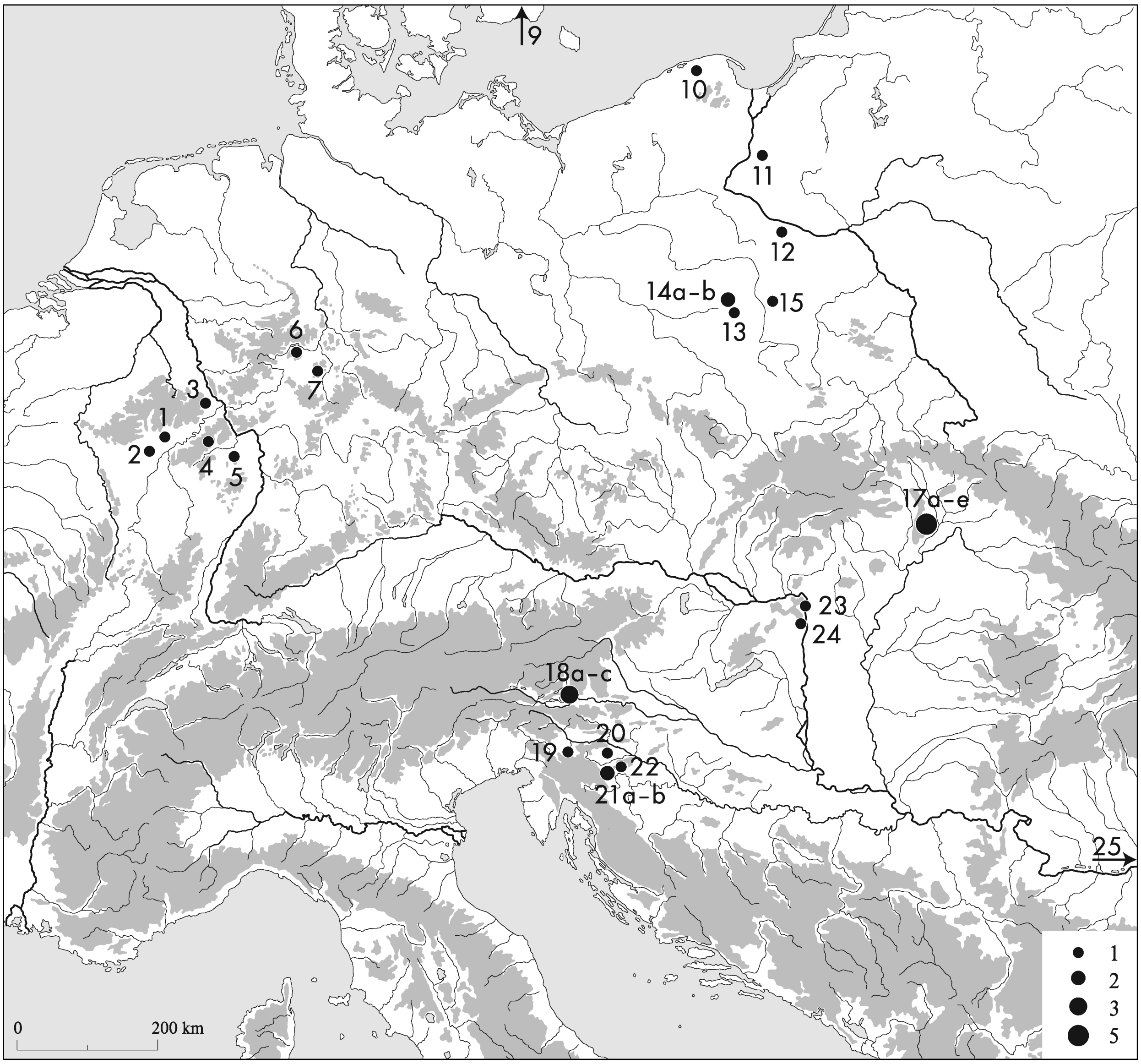

Fig. 2 *Map showing sites where scabbards with openwork copper alloy or silver plates or their fragments were found: 1 – Göblingen-Nospelt, 2 – Titelberg, 3 – Büchel, 4 – Wederath-Belginum, 5 – Badenheim, 6 – Großromstedt, 7 – Schkopau, 9 – Eggeby, 10 – Kopaniewo, 11 – Rządz, 12 – Stara Wieś-Kolonia, 13 – Ciecierzyn, 14a–b – Wesołki, 15 – Witaszewice, 17a–e – Zemplín, 18a–c – Magdalensberg, 19 – the River Ljubljanica, 20 – Strmec above Bela Cerkev, 21a–b – Verdun, 22 – Mihovo, 23 – the river Danube, 24 – Nagytétény, 25 – Belozem (map: from Istenič 2010, fig. 13).*

These scabbards originate in the La Tène tradition, as indicated by their construction from two metal plates and the way they are secured, by the campanulate top and the loop-plate, as well as the laddered chape, openwork decoration and the use of iron and copper-alloy (Istenič 2010, 142–145). Most of them are made of iron (back plate, laddered chape, suspension loop with loop plates) and copper-alloys (front plate and openwork plate), but there are also a few items entirely of copper-alloy and one of silver, as well as a copper-alloy scabbard with silver openwork plate (Istenič 2010, 139).

The swords belonging to these scabbards also exhibit La Tène characteristics, but the relatively long pointed tips of the blades, characteristic of Augustan to Tiberian and earlier Roman *gladii*, suggest a Roman influence. This is also indicated by two swords of the group with a name stamp on the upper part of their blade, *i.e.* the sword from grave 20 at Wesołki (Poland; Fig. 2.14) and another from grave 78 at Zemplín (Slovakia; Fig. 2.17). In both cases the stamps most probably refer to the maker of the sword. *Allius*, on the Wesołki sword, is no doubt a Latin name. The stamp *Utilici* on the Zemplín sword resembles the Latin adjective *utilis*, but there is no known Latin name that would correspond to the genitive or dative *Utilici* (Dąbrowski & Kolendo 1967, 390–395; Dąbrowski & Kolendo 1972, 62–64, fig. 2; Istenič 2010, 144, 148, list: 17b).

PREVIOUS SCIENTIFIC RESEARCH

Scientific study of the swords and scabbards from Zemplín (Fig. 2.8), Büchel and Badenheim (both Rhineland-Palatinate, Germany; Fig. 2.3, 5), all of them damaged by fire on the funeral pyre, was carried out by Pleiner (1993, 97–98, fig. 11, pl. 30–32), Schwab (2005) and Westphal (1998).

Metallographic analysis of the sword from Büchel showed that its quality was in no way superior to that of common Celtic swords (Schwab 2005, 334), challenging an important argument for locating the production of this group in the Norican region. Werner (1977, 386) and several others (most recently Böhme-Schönberger 1998, 240) assumed that richly decorated scabbards contained first-rate swords, which they associated with the high-quality Norican iron (*ferrum noricum*) mentioned by Pliny. The copper-alloy of the scabbard from Büchel is gunmetal (copper alloy with significant amounts of both zinc and tin; *cf.* Bayley 1990, 7, fig. 1) and contains zinc, tin and lead (Schwab 2005, 332).

Metallographic research on the sword blade with a name stamp from Zemplín (grave 78) showed it was decorated on the surface (Pleiner 1993, 97–98; Schwab 2005, 330). The copper-alloy of this scabbard was determined to be brass with 18% zinc; the analytical technique was not mentioned (Longauerová & Longauer 1990; *cf.* Istenič 2010, 123, footnote 2).

In his study of the scabbard from Badenheim, Westphal (1998) broached the interesting question of how the laddered chapes were made, but failed to give an answer. Haffner (1995, 140) suggested that the laddered chape of the scabbard from Büchel was made by forge welding. He also mentioned rivets seen on X-rays, suggesting that they fixed the chape to scabbard's front and back plate.

OBJECTIVES, RESEARCH STRATEGY AND TECHNIQUES EMPLOYED

Of particular interest to us was the information that the copper-alloy on the scabbard from Zemplín was brass with 18% zinc (note that all percentages in this paper refer to wt%) and the one from Büchel was gunmetal. This is extremely interesting as in the 1st century BC the use of brass in central and Western Europe was closely linked with the Romans. It is generally assumed that it was the Romans who spread the use of brass throughout Europe (Craddock, *et al.* 2004; Istenič & Šmit 2007). The link between the use of brass and the Romans is even closer in the case of pure brass, which typically contained about 20% zinc and very little lead and tin (*cf.* Craddock & Lambert 1985, 164; Jackson & Craddock 1995, 93–94). An exception to this seems to be the thin pure brass foils on the two stamps of the Isleworth sword from the River Thames, dated to the second half of the 3rd–2nd century BC (Stead 2006, 32–34, 168, 228, 48–49, Fig. 62, cat. no. 76). It suggests that in the decoration of very rare pre-Roman objects, tiny amounts of brass, supposedly produced in Anatolia, were used (Craddock & Cowell 2006).

Brass is also an important dating element. The Romans started to produce and use it about 60 BC (Istenič 2005, 189–190, 198–201; Istenič & Šmit 2007). Published analyses suggest that from the Augustan period, brass was widely used in coinage, Roman military equipment and brooches (Istenič 2009, 238, footnotes 12 and 13).

Our research also focused on the laddered chapes. In our opinion forge welding is a rather unlikely way of making them, because the inside of the chape is very narrow, and an appropriate anvil would be difficult to use. For the major part of the chape, the problem could be avoided by making a pipe-like chape and then flattening it. However, it is hard to imagine how the spur-like terminal could be formed by forge welding. Laddered chapes were not cast either, because iron forging, rather than casting, was in use in Europe during the Late Iron Age and Roman periods; cast iron would also be too brittle for such a chape (Manning 1976, 143; Tylecote 1992, 48; Craddock 1995, 235, 239).

Proton induced X-ray emission spectrometry (PIXE), carried out at the Tandetron Accelerator at the Jožef Stefan Institute in Ljubljana, was used to examine the composition of the non-ferrous metals from which parts of the scabbards and swords were made. The technique was applied to prepared areas of 3–4 mm^2, from which the corrosion layer had been removed as thoroughly as possible, down to the metal core, and also on unprepared areas.

As part of the research into the manufacture of the laddered chapes, binocular microscopy and X-radiography were applied to all the four scabbards, but did not yield useful results. Therefore the scabbard from the river Ljubljanica was carefully treated to remove the corrosion as well as the plastic parts added during restoration done in 1980. In addition, scanning electron microscope and optical microscope examination of polished and etched samples of the chape were carried out (*cf.* Istenič *et al.* 2011).

PIXE ANALYSES

PIXE used a proton beam in air, which provided simple irradiation of the spots selected for analysis (*cf.* Šmit *et al.* 2005a). The impact proton energy was 3 MeV; however, the protons lose energy in the aluminium exit window (8 μm thick) and the 1.2 cm air gap between the window and target, so the actual impact energy was 2.7 MeV. A Si(Li) X-ray detector was positioned at 45° with respect to the target normal at a distance of 5.7 cm. The X-ray spectra were measured through an absorber of 0.3 mm aluminium, which strongly attenuated the X-rays up to 10 keV, including the intense K lines of copper (8.04 and 8.9 keV). A proton current of a few nA was then applied, which enhanced production of hard X-rays. In this way it was possible to increase the sensitivity for mid-Z elements between silver and antimony to about 0.05%. The disadvantage of the thick aluminium absorber is the poor sensitivity for elements lighter than copper. For silicon detectors, the most critical element is iron, as its X-ray lines coincide with the silicon escape lines of copper. The two sets of lines were separated by the procedure of spectral fitting, although the separation of two overlapping Gaussian lines is generally subject to considerable uncertainties. The iron concentrations in our previous work were then uncertain by 0.5%. To overcome this difficulty we applied a procedure based on two sequential measurements at each point, using different absorbers. One measurement was made, as before, with the aluminium absorber of 0.3 mm, while the other exploited the 5.7 cm air gap as the only absorber. The intensities of X-ray lines obtained from the two spectra were then normalized according to the most intense copper K-alpha line, modelling the attenuation effects. The resulting X-ray intensities were then used in the standard single-spectrum code for evaluation of the elemental concentrations. For metals, the calculation relies on the normalization procedure of setting the sum of all concentrations to unity.

The area of the prepared (polished) measurement spots was about 3–4 mm^2, which is slightly larger than the area of the beam with a full width at half maximum (FWHM) of about 0.8 mm. Imprecise aiming of the beam would risk hitting the unprepared area. To avoid this, the beam size was reduced by a collimator of 0.3 mm diameter. In order to lessen beam broadening due to scattering in air, the collimator was positioned about 3 mm from the target. The reduced beam size was appropriate for the measurement of light elements, but it reduced the sensitivity for mid-Z elements. The reason for this was the intense bremsstrahlung radiation produced when the proton beam hit the collimator. The high energy spectra were therefore measured without the collimator, in spite of the broad beam size.

The proton current was about 1 nA and was set to give a counting rate of about 400 s^{-1}. This value did not completely prevent pile-up effects for copper K lines, which appear in the spectra as a continuous background extending up to about 17 keV. The pile-up contribution to the spectral background reduced the sensitivity for high-Z elements around lead and certain mid-Z elements (arsenic) to about 0.05%.

The measuring time was 5–10 minutes for a measurement with the aluminium absorber, and about 3 minutes for a measurement without it. The accuracy of the procedures was checked by analyzing the brass standard NIST 1107 as an unknown sample. The major concentrations were typically reproduced within a few percent, but increased the error to 10–20% on approaching the detection limits.

ANALYTICAL AND OTHER SCIENTIFIC RESULTS

The results of the PIXE analyses indicate that on all the four scabbards and associated swords the copper-alloy parts are of brass (Table 1). A large fraction of the iron (together with some tin and lead) measured on the prepared areas most likely originates from remnants of corrosion products on the measured surface or from corrosion layer on the surrounding unprepared surface, which could have been hit by the outer part of the proton beam during inaccurate aiming. Tin and lead namely often appear in corrosion products in higher concentrations than in the metallic core. The detection limit for tin was 0.1%; at tin values of 0.4% the statistical uncertainty of measurement was about 10%.

On the scabbard from the River Ljubljanica, only small differences could be observed between the analysis of the prepared and unprepared measurement spots (*cf.* Table 1.1–4). This can be explained by the fact that it is a riverine find and has no patina on the brass. The results suggest that the front plate and the openwork plate are of brass with ~16.4–16.8% zinc and ~0.7–0.8% tin, while the sword's campanulate hilt-end and knob lining, as well as the lowest rivet on the scabbard's suspension loop plate, are of brass containing a somewhat higher (~18.1–19.1%) zinc content and about ~0.9–1.1% tin (Table 1.1/2, 4, 5, 7, 8; Šmit *et al.* 2010, fig. 1).

Analytical results for the scabbard from Strmec above Bela Cerkev indicate that the front and the back plate, as well as the openwork plate, were made of brass containing ~21.1–22.3% zinc (Table 1.2/1, 4, 5; Šmit *et al.* 2010, fig. 2). The suspension loop is of brass with ~17% zinc (Table 1.2/8; Šmit *et al.* 2010, fig. 2). The tin contents are between ~0.5 and 0.7%. The patina is well preserved; the low values obtained for zinc on the unprepared surfaces (roughly between 3.5 and 5%; Table 1.2/2, 3, 6, 7) are a result of dezincification of the corrosion layer (*cf.* Šmit *et al.* 2010, fig. 2; Istenič & Šmit 2007, 143).

The front plate of the scabbard from grave 37 at Verdun is of brass with about 21% zinc (Table 1.3/2). The much smaller zinc value (~4.5%) measured in the patina was as expected (see above). Brass with ~15% zinc and ~0.4% tin was used for the lining of the knob at the end of the sword's tang (Table 1.3/1–3; Šmit *et al.* 2010, fig. 3).

The sword and its associated scabbard from grave 131 at Verdun are in poor condition. For this reason PIXE analyses were made only on a loose fragment of the scabbard's end. They indicate pure brass with a very high zinc content (~25.5%) for the front plate (Table 1.4/2; Šmit *et al.* 2010, fig. 4).

The study of the iron laddered chapes of four scabbards from Slovenia (Fig. 2.19–21) was begun with a careful inspection of their surface and X-radiography. This produced no indica-

object/ measure-ment spot	description	Fe	Ni	Cu	Zn	As	Ag	Sn	Sb	Pb	measure-ment details
1/1	scabbard, front plate, unprep.	0.62	0.14	81.1	16.7	n.d.	0.1	0.8	n.d.	0.68	B
1/2	scabbard, front plate, prep.	0.42	n.d.	81.3	16.4	n.d.	0.1	0.8	n.d.	1.00	A
1/3	scabbard, front plate, unprep.	0.59	n.d.	81.2	16.8	n.d.	0.1	0.7	n.d.	0.71	B
1/4	scabbard, openwork plate	0.41	n.d.	81.8	16.3	n.d.	0.1	0.7	n.d.	0.75	A
1/5	scabbard, rivet	0.34	n.d.	78.9	19.1	n.d.	0.15	1.1	n.d.	0.47	A
1/7	sword, knob-lining	1.54	0.11	77.8	18.5	n.d.	0.1	0.9	n.d.	0.98	A
1/8	sword, hilt end, unprep.	1.90	0.11	78.1	18.1	n.d.	0.1	0.9	n.d.	0.71	B
1/9	scabbard, lining beneath the lateral part of laddered chape; unprep.	3.57	0.13	90.8	4.60	n.d.	0.04	0.4	n.d.	0.42	A
1/11	scabbard, copper alloy in the 3rd rung; unprep.	4.2	n.d.	87.9	0.49	n.d.	0.17	7.1	0.09	0.15	C
1/12a	scabbard, copper alloy in the 2nd rung; unprep.	2.98	0.2	92.8	0.47	n.d.	n.d.	3.6	n.d.	n.d.	A
1/13	scabbard, copper alloy beneath the 4th rung; unprep.	4.14	0.1	88.9	0.86	n.d.	0.12	5.7	n.d.	0.11	B, mask
1/14	scabbard, lining beneath the lateral part of laddered chape; unprep.	5.11	n.d.	88.0	n.d.	n.d.	0.20	6.3	0.33	0.11	A
1/15	scabbard, copper alloy in the 4th rung; unprep.	7.13	n.d.	87.6	n.d.	n.d.	0.09	4.7	n.d.	0.48	B
2/1	front plate, prep.	0.43	0.14	77.5	21.1	0.09	n.d.	0.5	n.d.	0.22	A
2/2	front plate, unprep.	1.31	n.d.	92.0	4.50	0.20	n.d.	1.3	n.d.	0.66	B
2/3	back plate, unprep.	2.02	n.d.	93.4	3.69	0.10	n.d.	0.5	n.d.	0.23	B
2/4	back plate, prep.	0.35	n.d.	76.4	22.3	0.11	n.d.	0.7	n.d.	0.19	A
2/5	openwork plate, prep.	0.33	n.d.	77.2	21.4	0.14	n.d.	0.7	n.d.	0.24	B
2/6	openwork plate, unprep.	2.30	n.d.	90.2	4.94	0.26	n.d.	1.8	n.d.	0.45	B
2/7	suspension loop plate, unprep.	2.25	n.d.	91.1	4.55	0.20	n.d.	1.7	n.d.	0.20	B
2/8	suspension loop plate, prep.	0.98	n.d.	81.1	17.0	0.13	n.d.	0.6	n.d.	0.26	A
3/1	scabbard, front plate, unprep.	1.64	0.12	92.3	4.56	n.d.	0.07	1.2	n.d.	0.09	B
3/2	scabbard, front plate, prep.	0.76	0.10	77.8	20.7	n.d.	0.05	0.5	n.d.	0.13	B
3/3	knob-lining. prep.	0.27	0.10	83.4	15.4	n.d.	0.09	0.4	n.d.	0.37	B
4/1	scabbard, front plate, unprep.	1.14	0.14	87.9	9.31	n.d.	0.17	1.0	n.d.	0.32	B
4/2	scabbard, front plate, prep.	0.18	0.14	73.3	25.5	n.d.	0.06	0.6	n.d.	0.36	A

Table 1 *Elemental concentrations (in wt%) measured by PIXE on the scabbards and associated swords from the river Ljubljanica (1), Strmec above Bela Cerkev (2), Verdun near Stopiče, grave 37 (3) and grave 131 (4). Analyses have been carried out on the prepared or unprepared surfaces (abbreviated prep. and unprep.). They have a precision of a few percent for the major elements and about 10% for the minor elements. The detection limits for As and Pb are 0.05%, for Zn 0.4% (due to the interference with strong Cu lines), for Ni and the elements heavier than Ag 0.05–0.1%. The detection limits for Fe depend on measurement details: 0.05% for A, B and 1% for C. Not detected elements: n.d. Measurement details: A – soft X-ray spectrum was obtained by a narrow beam of 0.3 mm, hard X-ray spectrum by a broad beam of 0.8 mm FWHM; B – both soft and hard X-ray spectra were obtained by a broad beam; C – only hard X-ray spectrum by a broad beam was measured. During the measurement of spot 13 on the scabbard from the river Ljubljanica, its surrounding was covered by an aluminium foil (mask).*

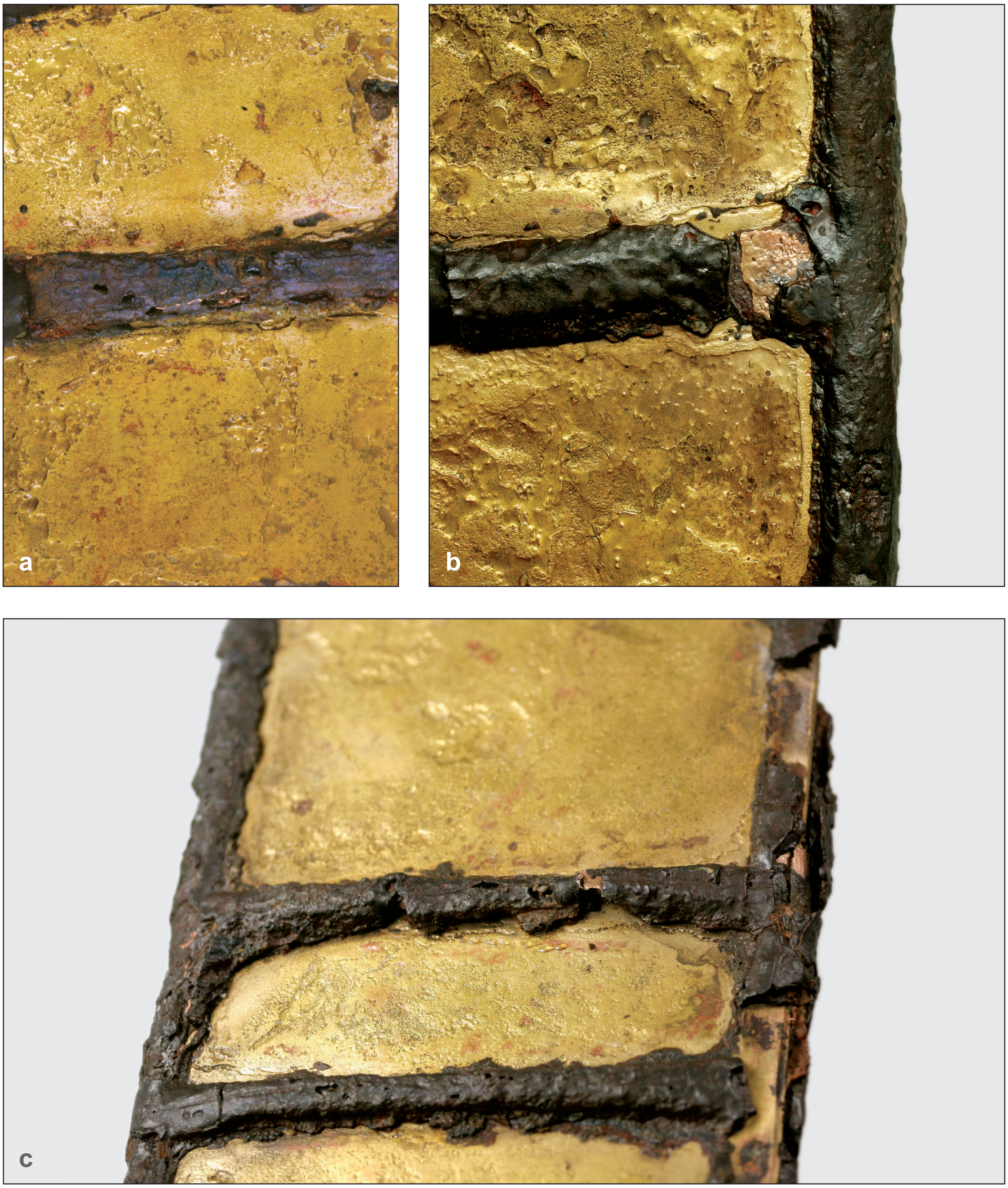

Fig. 3 *Bronze layers in iron bridges on the front of the scabbard shown in Fig. 1: a – in the 2nd bridge; b – in the 4th bridge; c – in the 9th bridge (bronze layer in the V-shaped lateral part of the chape is also visible; cf. Fig. 4). Not to scale (width of the photographed bridges is 0.4–0.5 cm (photos: S. Perovšek, Narodni Muzej Slovenije).*

tion that they were welded, soldered or riveted. A meticulous examination of the laddered chape of the scabbard from the Ljubljanica, which included removal of corrosion layers and several plastic parts added during conservation in 1980, was described in detail in Istenič *et al.* (2011). It revealed less than 0.1 mm thick layers of copper-alloy in the front bridges of the chape (Fig. 3a–c). Analyses of these alloys showed they were all bronze with an inho-

Fig. 4 *Bronze layer in the V-shaped lateral part of the iron laddered chape. Not to scale (photo: S. Perovšek, Narodni Muzej Slovenije).*

mogeneous tin content fluctuating between ~4 and 7% (Table 1.1/11, 12a, 13, 15; Šmit *et al.* 2010, fig. 1). A review of the restoration work also revealed a thin copper-alloy lining inside the V-shaped lateral part of the laddered chape on the left and the right side of the scabbard, at the height of the 9th front bridge and the 12th–13th back bridge, respectively (Fig. 4 and 5). According to the analyses, the lining on one side (right) was of bronze with about 6% tin, and on the other side (left) of brass with about 5% zinc (Table 1.1/9, 14; Fig. 3–4; Istenič *et al.* 2011, figs. 2–4).

In one of the front bridges, a small part had split revealing two cross-sections, in which two and three bronze layers were discernable, respectively (Fig. 6–7). This fragment and another one from the bridge at the back of the scabbard were prepared for metallographic analysis; the results were presented in detail in Istenič *et al.* (2011).

In the sample of the front bridge, three practically uncorroded and very thin (about 0.02–0.05 mm) layers of tin bronze were observed in the cross section (Fig. 9.a–b). The hardness of this bronze was about 96 HV 0.2. Its dendritic microstructure and inhomogeneous elemental composition (the highest measured tin value was ca. 8% and the lowest ca. 3.1%) indicate it was applied molten, *i.e.* as a liquid. The lower surface (orientation as in the cross section, *cf.* Fig. 8) of the bronze lamellae indicates inter-crystalline diffusion of copper and tin into the steel. All these observations clearly indicate that bronze was used as a solder in the front bridges, *i.e.* the copper-alloy was brazing metal.

A core of steel could also be observed in the cross section of the front bridge (Fig. 8 and 10). It contains 0.3–0.4% carbon, its microstructure consists of ferrite and pearlite, and its hardness lies between 130 and 135 HV 0.2.

The steel core in the sample from the bridge on the back of the laddered chape is better preserved. It shows a microstructure of a low carbon steel (<0.1% C) with small volume fractions of pearlite and grain-boundary cementite (Fig. 11). Its hardness is between 112 and 118 HV 0.2. A longitudinal section revealed various elongated slag inclusions. Their form and orientation suggest the object was forged, with strokes coming approximately from the up/down direction with respect to the orientation of the sections through the sample.

Fig. 5 *Brass layer in the frame of the iron laddered chape. Not to scale (photo: S. Perovšek, Narodni Muzej Slovenije).*

DISCUSSION

Copper-alloy parts of all the four examined items from Slovenia and the one from Zemplín are of brass, while the scabbard from Büchel is of gunmetal (see above). According to the information kindly provided by R. Schwab, who analysed the copper-alloys of the scabbards from Wederath-Belginum (Fig. 2.4) and Badenheim (Fig. 2.5), the compositions are as follows:

- Badenheim: 87% Cu, 12% Zn, 0.23% Sn, 0.1% Pb (ED-XRF analysis of a small sample)
- Wederath-Belginum: 86% Cu, 12.6% Zn, 0.4% Sn, 0.4% Pb (ED-XRF analysis)

In both cases, the scabbards were damaged by fire on the funeral pyre, which caused evaporation of zinc. This seems to provide an explanation for the low value of zinc in brass, in which the small concentration of lead and value of tin much below one percent suggest that it was pure brass (*cf.* Jackson & Craddock 1995, 93; Riederer 2002, 132, table 46, cat. 1488).

In three cases (Strmec above Bela Cerkev, Verdun grave 37 and Verdun grave 131; Table 1.2–4) the brass contains more than 20% zinc and less than 1% of tin and lead, suggesting that undiluted brass obtained from brass ingots, rather than from melted brass objects, were used for their manufacture (*cf.* the ingot from Haltern: Riederer 2002, 132, table 46, cat. 1488; Müller 2002, 132, table 46: 1488). The zinc value of ~ 25% obtained for brass of the scabbard from grave 131 at Verdun is the highest zinc value we have encountered in our analyses of Roman brass (*cf.* Šmit & Pelicon 2000; Šmit *et al.* 2005b) and corresponds well to the highest zinc values of Roman brass known from published evidence (*cf.* Jackson & Craddock 1995, table 6: gladiator helmet; Ponting 2002, table 1: 17; Riederer 2002, 112, 115, 116, tables 6: cat. 43, 44, 53, table 14: cat. 105, 106, 132, 133, 190, table 29: cat. 824, table 32: cat. 860; in a few cases where the value of brass is above 28% – ex. Riederer 2002, 123, 129, table 23: cat. 561, table 36: cat. 1002 – the arguments for classification of the objects as Roman should be checked). A theoretical upper limit for the zinc content in Roman brass, made by the cementation process is about 28% (Craddock 1995, 296–298; Craddock & Lambert 1985, 164). In the cases of Zemplín, Wederath-Belginum and Badenheim the analytical results also suggest, or at least

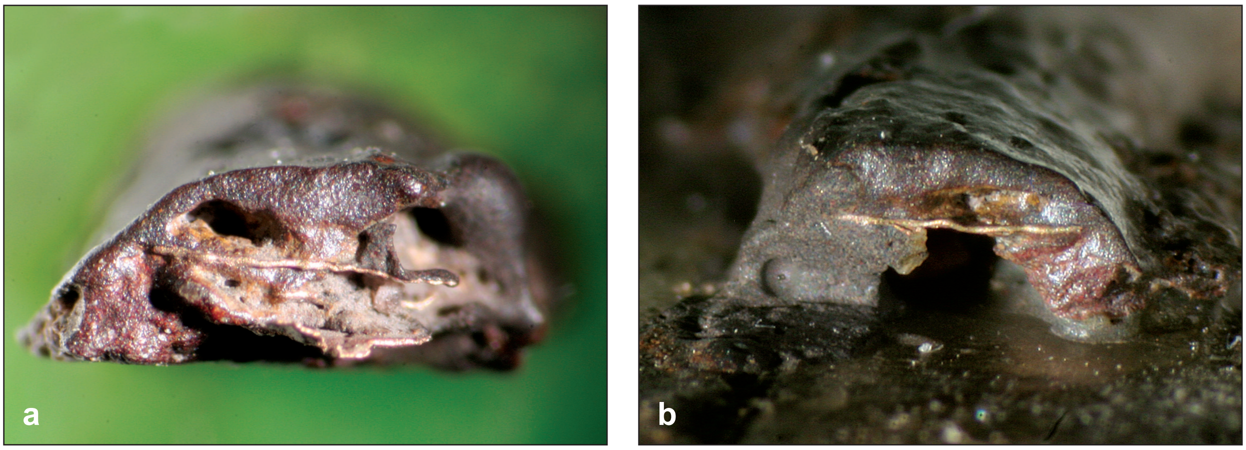

Fig. 6 *Bronze layers in the cross-sections of the 3rd front bridge of the laddered chape: a – cross-section of a broken-off fragment; b – cross-section of the part of bridge that remained on the scabbard. Not to scale (photos: S. Perovšek, Narodni Muzej Slovenije).*

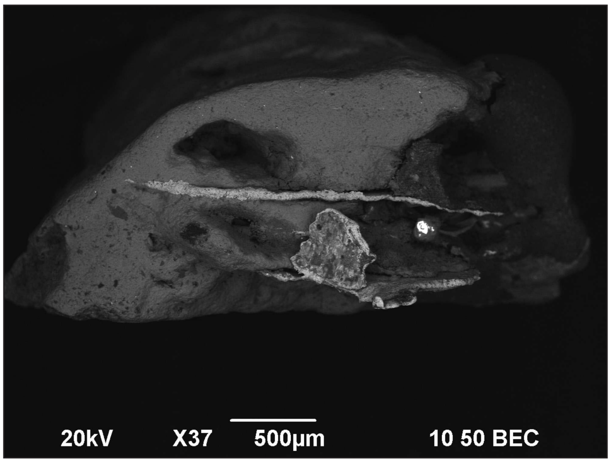

Fig. 7 *Bronze layers in the cross-section of a fragment of the 3rd front bridge of the laddered chape, not polished. SEM, BSE mode (from Istenič et al. 2011).*

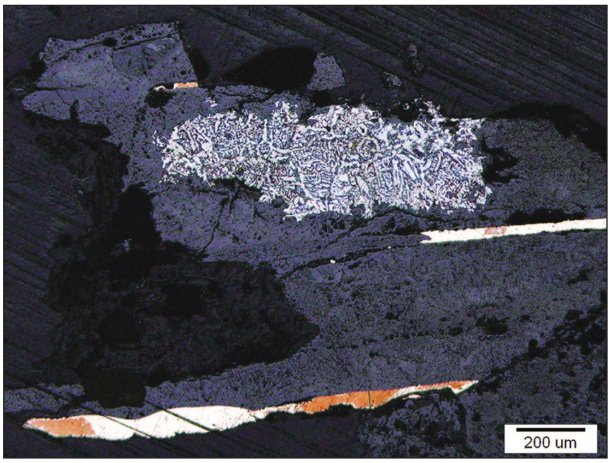

Fig. 8 *Cross-section of a fragment of the 3rd front bridge of the laddered chape. The surface was polished and etched with a solution of iron (III)-chloride and HCl in ethanol. Three thin layers of bronze and the iron core (light grey) are clearly visible in the corrosion products (dark grey). Optical microscope (from Istenič et al. 2011).*

do not refute, the use of brass ingots for their production. Only in one case (the scabbard from Büchel) not brass but gunmetal, most probably obtained by melting brass and bronze objects together, was used.

There is no indication that the Celts produced brass, but the Romans did produce and use it from about 60 BC (Istenič 2005; Istenič & Šmit 2007). In our opinion, therefore, the use of pure brass, probably from ingots, in the early Augustan age indicates that these scabbards and swords were manufactured in a Roman environment or in (close) contact with it. This is also suggested by the pointed tips of the sword blades and the Latin name of the manufacturer for at least one of the swords. On the other hand, the general shape of the scabbards and swords under discussion firmly follows the La Tène tradition.

To put the use of brass in the group of scabbards and swords under discussion into a wider context, other cases of the use of brass for pre-Roman objects should be mentioned. From the

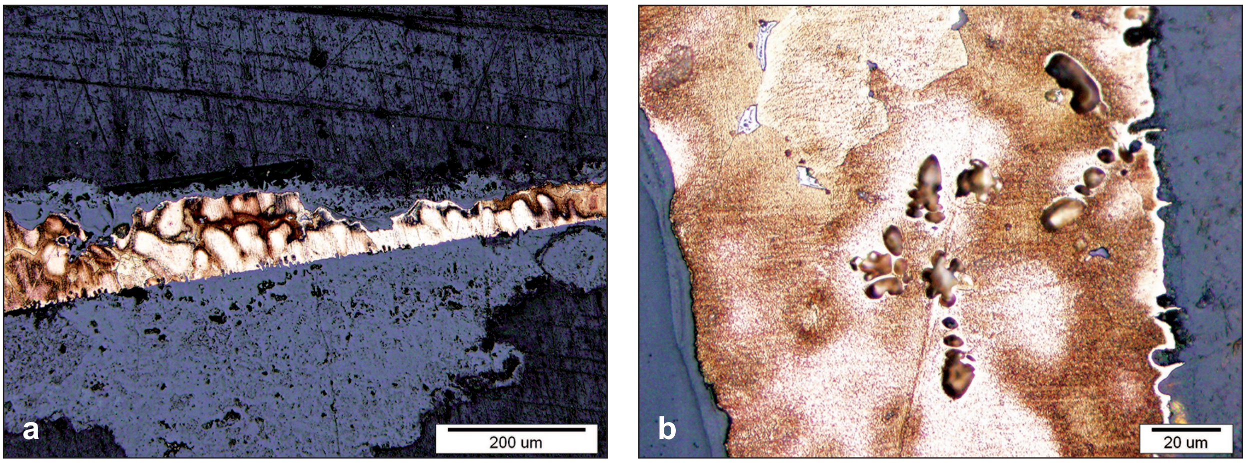

Fig. 9 *The microstructure of the bronze layer in the 3rd front bridge (cf. Figs. 6–7) of the laddered chape shows it was melted. The lower surface (oriented vertically in Fig. 8b) shows intercrystalline diffusion of bronze into iron. The coloration indicates the leakage of tin: brighter areas contain more tin, darker ones less. Crystal grains of a solid solution of tin in copper and small dendrites of a phase rich in iron are visible, as well as peritectic δ. Longitudinal section. The surface was polished and etched with a solution of iron (III)-chloride and HCl in ethanol. Bright field illumination (from Istenič et al. 2011).*

scarce published evidence regarding the elemental composition of pre-Roman metal objects in continental Europe, brass occurs in the group of Late La Tène swords with iron or copper-alloy discs on the tang. These swords seem to be roughly contemporaneous with the swords and scabbards discussed in this paper. They appear on the north-eastern periphery of Gaul and also to the east of the Rhine (Haffner 1989, 229–238; Roymans 2004, 108–112, figs. 7.4, 7.5). Few analyses of copper-alloy discs have been made. They showed that the discs from three swords from the Netherlands were of bronze (Verwers & Ypey 1975, 87, 88, tab. 1), while the analysed disc from the sword from the river Scheldt near Denain (Departement Nord, France), and another one from the sword from Rögatz (Saxony-Anhalt, Germany) were of brass (Hantute & Leman-Delerive 1982, 90; Verwers & Ypey 1975, 90–91).

Copper-alloys in Late Iron Age Britain are better known and indicate that brass and gunmetal began to be used for metalwork in the period shortly before the start of the Roman conquest, at the earliest in southern England, where the earliest brasses do not pre-date the beginning of the 1st century AD. Brass was obtained from the Roman world (Dungworth 1996, 407–411). Among other objects, it occurs in pre-Roman swords and their scabbards (Dungworth 1996, 408–409, fig. 18; Stead 2006, 3, table 1). Such is the case with five swords and scabbards from the South Cave cache in Yorkshire, found in 2002. Analyses of copper-alloys of these objects indicate they are pure brass, in some cases straight from ingots. The availability of brass north of the river Humber in the period to which the swords and scabbards are dated, *i.e.* to ca. AD 70, must have been dependent on contacts with the Romans further south (Northover, n.d.).

It can be concluded that there are several examples of the use of brass in the manufacture of pre-Roman indigenous weapons. They appear in the period of close contacts shortly before, or after, the start of Roman conquest. Brass originated from imported Roman brass objects or ingots.

To our knowledge, the scabbards with openwork plate and the corresponding swords discussed in this paper are the only typologically pre-Roman (Celtic) group of objects in which the use of pure brass seems to be regular, as it appears in seven (from Zemplín, Badenheim, Wederath-Belginum and four from Slovenia) of the eight scabbards analysed. The copper-

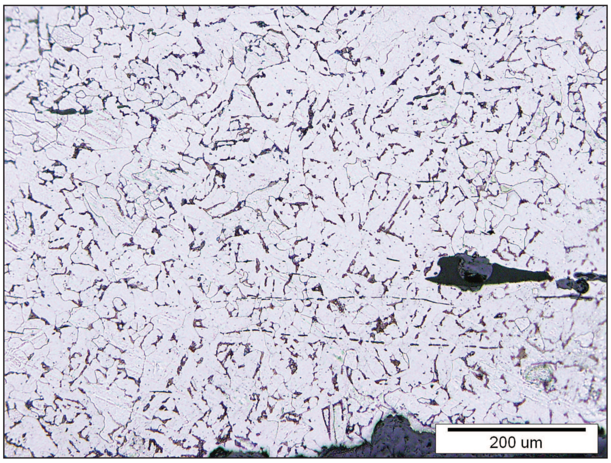

Fig. 10 *Microstructure of iron core in the 14th back bridge of the laddered chape, longitudinal section (etched with 2% nital). Bright field illumination (from Istenič et al. 2011).*

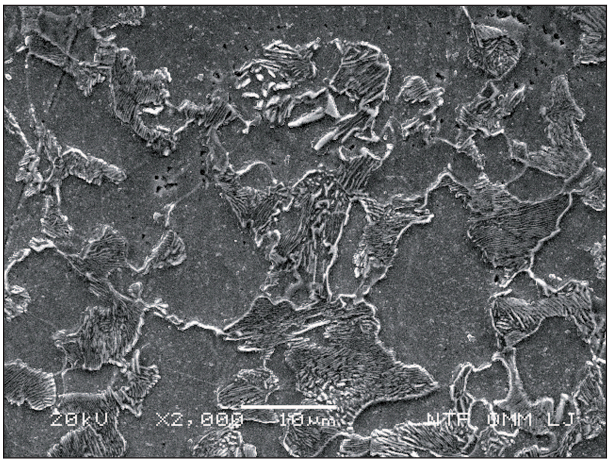

Fig. 11 *Microstructure of iron core in the 3rd front bridge of the laddered chape, cross-section (etched with 2% nital). SEM, SE mode (from Istenič et al. 2011).*

alloy of the eighth scabbard (Büchel) was probably obtained from pure brass to which tin and lead were added, possibly through melting with bronze. In comparison with the use of brass in pre-Roman objects in Britain and northern Europe mentioned above, they had a much wider distribution. In addition, a Roman manufacturer's name appears on one of the swords of the group. These arguments allow the supposition that the scabbards with openwork plates and the associated swords were manufactured in a Roman milieu, in a region where relations between Celts and Romans were close and from where a wide distribution of products to the territories indicated by the find locations of these items can be expected. In our opinion, the eastern part of *Gallia Cisalpina*, the province which became part of Italy in 42 BC, seems to best meet these requirements. The fact that this type of scabbards and swords accommodated Celtic requirements would suggest that they were intended for the Celts and others who appreciated Celtic swords and were accustomed to using them.

The distribution of the scabbards under discussion, which are concentrated in the eastern part of the Celtic and in Germanic regions, does not necessarily reflect relations between the Celts and their eastern neighbours, which was hitherto a generally accepted view (Böhme-Schönberger 1998, 243–248; Czarnecka 2002, 95–96; Łuckiewicz 2000, 375). It seems to be equally or more plausible that they indicate Roman links to the peoples, with whom they had more or less close relations in the last decades BC.

In the case of the *Treveri* and *Taurisci*, we can assume the scabbards and swords under discussion were most likely used by their leaders, who fought on the side of the Roman army. Their weapons were still completely traditional; only the scabbards and swords exhibit – in addition to predominant La Tène elements – clear Roman features.

Metallographic analyses clearly show that the front bridges of the laddered chapes were brazed, suggesting how they were made. However, the three layers of bronze, *i.e.* solder, found in the sample, are surprising, as they seem to suggest that four layers of very thin (ca. 0.4 mm) steel sheet were soldered.

Soldering of the U-shaped lateral part of the laddered chape, symmetrically on the left and the right side at approximately half its presumed original length (*cf.* Istenič 2010, 140) with bronze and brass, respectively, suggests that the chape was made of two parts (the lower and the upper one) that were joined by brazing.

CONCLUSIONS

The findings described in the paper seem to suggest that Roman craftsmen manufactured scabbards with openwork plate and the associated swords. These swords and scabbards were made in the Celtic tradition, to accommodate Celtic taste, but used material typical of Roman weapons (brass) and enhanced the form of the sword blade (pointed tip). Presumably they were intended for the elite of client (mostly Celtic) tribes and others, who liked such weapons and to whom Romans wanted to show favours, for example with presents.

Metallographic analyses of the scabbard from the River Ljubljanica indicate that the laddered chape was soldered at the front bridges; surprisingly they seem to suggest that the front bridges were made of four very thin steel sheets (ca. 0.4 mm thick) soldered together. They also showed that the laddered chape was made of two halves that were joined by soldering the U-shaped lateral part of the chape at two points, symmetrically on the left and the right side of the chape.

LIST OF SCABBARDS AND SWORDS

List of scabbards and swords mentioned in the text and their basic bibliography.

Slovenia			
1	the river Ljubljanica	scabbard and associated sword	Istenič 2010, 125–127, figs. 2–3, insert 1; Šmit *et al.* 2010, 165–169, table 1, fig. 1; Istenič *et al.* 2011
	Strmec above Bela Cerkev	scabbard and associated sword	Istenič 2010, 127–131, figs. 4–7, insert 2; Šmit *et al.* 2010, 167–169, table 2, fig. 2
3	Verdun, grave 37	scabbard and associated sword	Istenič 2010, 131–133, figs. 8–9, insert 3; Šmit *et al.* 2010, 169–171, table 3, fig. 3
4	Verdun, grave 131	scabbard and associated sword	Istenič 2010, 133–136, figs. 10–11, insert 4; Šmit *et al.* 2010, 170–171, table 4, fig. 4
Germany			
5	Büchel, grave	scabbard and associated sword	Haffner 1995, 137–142, 148, figs. 2, 3, 9.1, Falttafel 1; Schwab 2005
6	Badenheim, grave	scabbard and associated sword	Böhme-Schönberger 1998, 218–223, figs. 11–13, Beilage 4; Westphal 1998
7	Wederath-Belginum, grave 784	scabbard and associated sword	Haffner 1995, 141–143, figs. 4, 9.2, pl. 1
Slovakia			
8	Zemplín, grave 78	sword with a stamp and remains of a scabbard	Budinský-Krička & Lamiová-Schmiedlová 1990, 255, fig. 20a, pl. 11.20; Lamiová 1993, 25, 27, fig. 18, 19, 25; Pleiner 1993, 97; Longauerová & Longauer 1990; Istenič 2010, 144
Poland			
9	Wesołki, grave 20	sword with a stamp and remains of a scabbard	Dąbrowska & Dąbrowski 1967, 27–28, fig. 23.6, 7, pl. 8.3; Istenič 2010, 144

ACKNOWLEDGEMENTS

The authors would like to thank the anonymous referee and Dr. Roland Schwab for their invaluable comments on the paper.

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