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## **Celtic gold torcs - An interdisciplinary and diachronic perspective**

Barbara Armbruster, Marilou Nordez, Maryse Blet-Lemarquand, Sebastian Fürst, Nicole Lockhoff, Pierre-Yves Milcent, Sylvia Nieto-Pelletier, Martin Schönfelder, Roland Schwab

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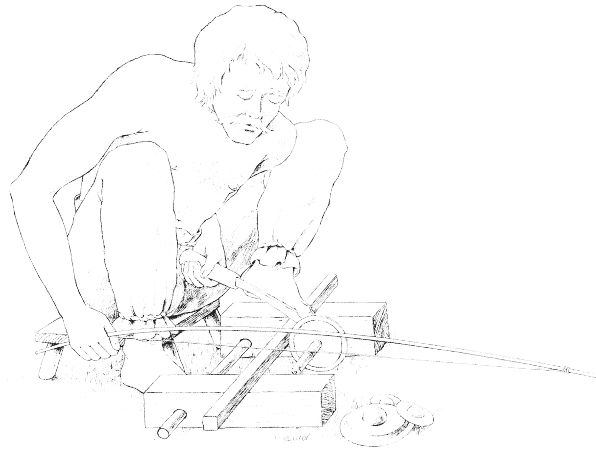
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## Preface

The International Conference „Archaeometallurgy in Europe”, held at Miskolc in Hungary from the 19<sup>th</sup> to the 21<sup>st</sup> of June 2019 is by now a well-known and fully established international scientific meeting, at which scholars with different backgrounds can present their research on ancient metal finds, metal analysis, ancient mining, the reconstruction of various kinds of production processes, ancient technologies and every topic that belongs to metals and their transformation from ore to objects.

Our meeting at Miskolc was the fifth of a series that begun in Milan in 2003, followed in 2007 by the conference in Aquileia, both in Italy. The third was held at Bochum, in Germany, in 2011 and the fourth at Madrid, Spain, in 2015. The special aim of our 2019 conference was that of emphasizing and strengthening the interdisciplinary character and the various activities in the field of archaeometallurgy and widening the focus towards Eastern Europe.

The papers we present in this volume use scientifically collected data that allow the re-examination of aspects of archaeology and offer a view of antiquity based on materials science, supplemented by archaeological, literary and stylistic evidence, i.e. the methods by which human activities have been reconstructed in the past.

The presentation of research, availability of information, discussion and confrontation is an important side of this conference. Publishing new data and research in this frame - although in some cases only in short form - is important. The volumes of the conference „Archaeometallurgy in Europe” have been planned as a window on the world of archaeometallurgy, as general information for students, scholars and in general for anyone interested in these topics and, finally, as a tangible historical memory of the kind of studies carried out at this time. We all know that

research can be dated, just like the ancient objects we are studying. For these reasons and more, even though we received a good number of submissions, it is a pity that some interesting papers presented at Miskolc were not delivered for publication in this volume. Apparently, as it transpired at the conference, some of the authors decided to publish in a journal with impact factor. Nevertheless, a shorter or different version could have been submitted for publication in this volume as well, in particular as we know that the collection of papers, the peer-reviewing, corrections and the printing process normally take a couple of years. These volumes play an important role for our scholarly community, because they also represent an occasion for valuable corrections and discussion on weak points during the peer-reviewing stage, which is always carried out by two specialists in the field of the topic, while most journals with impact factor simply use their own reviewers, who do not know a thing about ancient metallurgy. The result is that the papers published in some journals are often less than mediocre.

We hope that the next volumes of this series will collect a larger number of papers presented at the conference, and we will be able to demonstrate once again that the frame within which archaeology can be studied is - and will be in the future - greatly enhanced by archaeometallurgical research.

We are very grateful to all reviewers and especially to the English native speakers who took the time to check the language of the papers in this volume.

To all of you a heartfelt thank you!

The editors



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Ivelin KULEFF (Bulgaria)  
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Barbara ARMBRUSTER (France)  
Vasiliki KASSIANIDOU (Cyprus)

At the meeting of the Standing Committee that took place during the conference, Béla TÖRÖK (Hungary), Jiří HOŠEK (Czech Republic) and Miljana RADIVOJEVIĆ (UK) were nominated for membership of the Standing Committee and accepted, and an Advisory Committee without voting right was established.

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Miskolc City Transportation Company

and

The Historical Metallurgy Society

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# **Celtic gold torcs - An interdisciplinary and diachronic perspective**

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## **Abstract**

This contribution deals with Iron Age gold torcs from the Western La Tène culture (mid 5<sup>th</sup> to 1<sup>st</sup> century BC). Torcs are generally associated with the Celtic warrior, as well as with the religious, symbolic and economic spheres. Representations of torcs are known from anthropomorphic statuary carved in stone and wood, or worked in bronze and silver, and they are mentioned in Greek and Roman textual sources. These annular ornaments are mainly discovered in hoards, sanctuaries or funeral contexts and particularly well represented in the archaeological record. The purpose is to present the diversity of find contexts and the large range of sources available that extend our understanding of how gold torcs were worn and allow a glimpse on their social, economic, ritual and symbolic value. At the beginning of the 3<sup>rd</sup> century BC coinage arises. Accordingly, the specific relation between gold torcs and coins is also raised. The diachronic view of the study covers torcs from the 6<sup>th</sup> to the 1<sup>st</sup> century BC. The interdisciplinary approach to these emblematic objects includes various methods from archaeological science (SEM, XRF, LA-ICP-MS), typo-chronology, tool-mark analyses, manufacturing techniques, experimental archaeology and iconography. The paper scrutinizes the evolution of torcs in style, material composition and technology, as well in the depositional practice in time and space during the Iron Age. The case studies presented concern gold torcs from continental Europe, in particular from Belgium, France, Germany and Switzerland.



# Celtic gold torcs - An interdisciplinary and diachronic perspective

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Maryse Blet-Lemarquand  
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## Introduction

This paper deals with Iron Age torcs studied within the French-German ANR-DFG research project "CELTIC GOLD. Fine metal work in the Western La Tène culture" (2017-2021) (ANR-16-FRAL-0001). It is financed by the French "Agence Nationale de la Recherche" (ANR) and the German "Deutsche Forschungsgemeinschaft" (DFG), coordinated by B. Armbruster (CNRS-TRACES, Toulouse) and R. Schwab (CEZA, Mannheim). One of the aims of this interdisciplinary program is to renew the perception of the Western La Tène culture on the continent (mid 5<sup>th</sup> to the 1<sup>st</sup> century BC) through research on production and consumption of gold objects. The project focuses on a wide geographic area, namely Austria (A), Belgium (B), the Channel Islands

(UK), France (F), Germany (D), Luxembourg (L), the Netherlands (NL) and Switzerland (CH), and involves a large variety of economic, social, technological, and stylistic aspects. Two archaeometry laboratories are involved in the analytical approaches, namely the "Institut de Recherche sur les Archéomatériaux – Centre Ernest-Babelon" (IRAMAT-CEB Orléans, France) and the "Curt-Engelhorn-Zentrum Archäometrie" (CEZA Mannheim, Germany).

Torcs are emblematic objects of the Iron Age, often associated with warrior representations, religious, symbolic and economic spheres. 105 gold torcs from 68 different sites within our study area in Continental Europe, dating from the 6<sup>th</sup> to the 1<sup>st</sup> century BC, are considered in this research (Fig. 1).

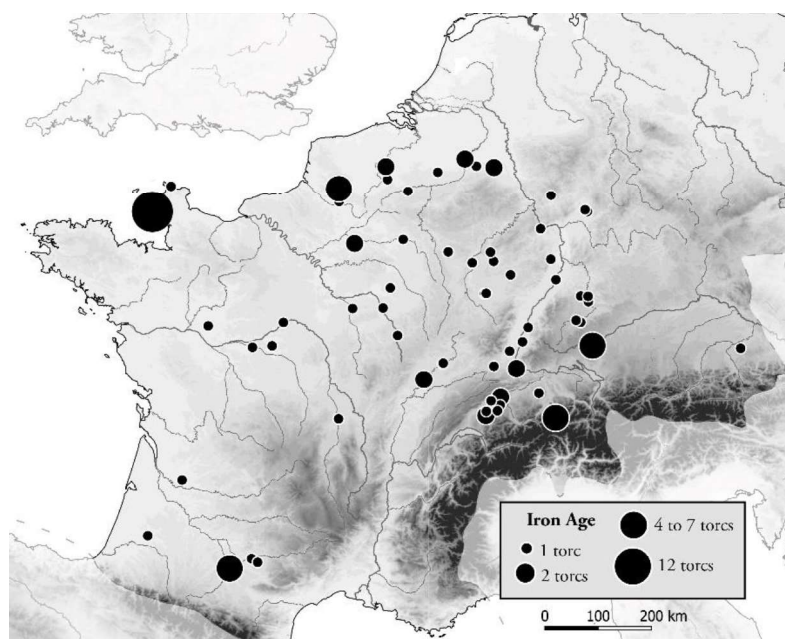


Fig. 1: Distribution map of Iron Age gold torcs in Western Continental Europe (© M. Nordez)

## Interdisciplinary approach

The interdisciplinary approach of the “Celtic Gold” project allows a comprehensive view of the Iron Age torcs (Fig. 1) from various perspectives. In the present work, archaeological, stylistic, manufacturing and chemical aspects are presented within their chronological framework. Due to the high-intrinsic value of the gold objects, only non-destructive or minimal-invasive analytical techniques were applied. The examination of the technological aspects is mainly based on optical investigations at several levels, tool mark analyses and the inspection of the surface topography by macro and microphotography. High-resolution imaging techniques, such as scanning electron microscopy, complement these studies and help to answer specific questions that require higher magnifications, such as the identification of rough casting surfaces or solder joints. By determining the metal composition, it is possible to identify various material groups and, for instance, to gain information about metal batches within a find ensemble (Blet-Lemarquand et al. 2018).

The chemical composition was mainly determined with laser-ablation inductively coupled plasma mass-spectrometry (LA-ICP-MS). This minimal-invasive technique enables analysis of deeper layers of the unaltered original metal alloy. Additionally, LA-ICP-MS is more sensitive than X-ray-based techniques. However, it requires a small sample taken by the laser ablating through the depleted surface down to the unaltered metal while monitoring simultaneously the change in the alloy composition in a so called “time resolved signal” of the ICP-MS. This sampling area of around 0.04-0.08 mm is invisible without higher magnification (Fig. 2b). Nevertheless, the minimal-invasive properties of this method are limited to the size of the sample cell of the laser system. To overcome this limitation, large sample cells that are able to receive several or large objects were developed at the IRAMAT-CEB laboratory (Fig. 2a; Blet-Lemarquand et al. 2018). In future, portable LA-devices ablating under air-conditions could offer another possibility for the direct ablation of huge objects, not only in the lab but also directly in the museum (Glaus et al. 2012).

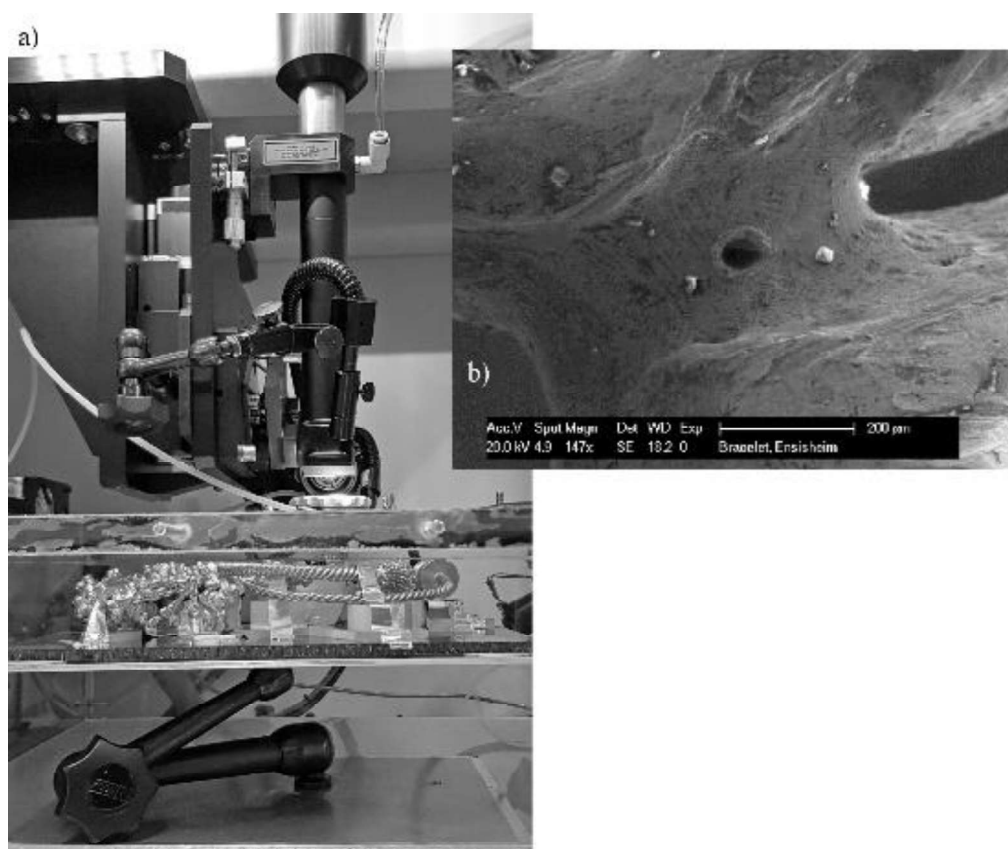


Fig. 2: a) Large cell developed by the IRAMAT-CEB laboratory (© M. Nordez)  
b) View of a micro-ablation (80  $\mu\text{m}$ ) on the gold bracelet of Ha D3 from Ensisheim (Haut-Rhin, F) analysed in the framework of the ANR-DFG West Hallstatt Gold project (ANR-11-FRAL-0013) (© M. Blet-Lemarquand)

### The closed torcs of the Early Iron Age (6<sup>th</sup> century BC)

The main characteristics of the torcs of the period Hallstatt D2 (2<sup>nd</sup> half of the 6<sup>th</sup> century BC) are a closed annular and hollow shape (Fig. 3b) and geometric ornamentation: 18 objects with these attributes are recorded for this period (Armbruster 2018, Tab. 1; Hansen 2010; Milcent et al. 2018). The shape and relief result from the plastic shaping of a gold sheet cylinder using a spinning lathe (Armbruster

2018). The punched decoration bears common patterns known from the end of Early Iron Age goldwork in general. Contrary to their large appearance, the average mass of these torcs is rather low (96 g, masses between 40 and 240 g): only a small amount of gold is needed for their fabrication compared with the later Iron Age torcs. The fact that they are mostly closed in shape requires that their internal diameter is large enough to be threaded over the head: their average internal diameter is therefore larger than for the following periods, around 190 mm.

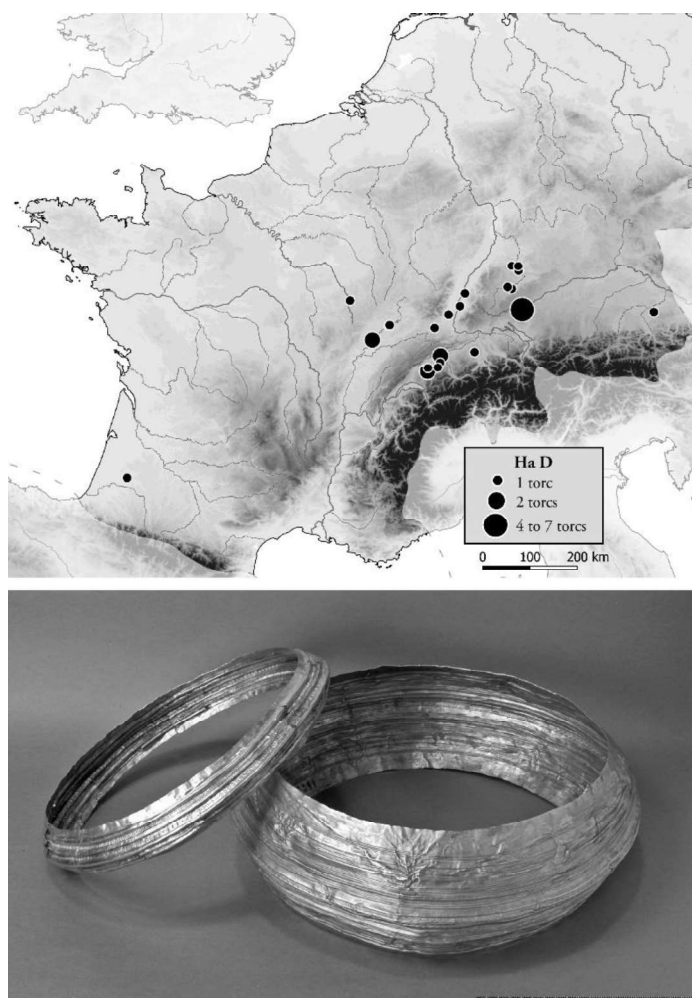


Fig. 3: a) Distribution map of Ha D gold torcs (© M. Nordez)  
b) Torcs from graves 1 and 2 of Apremont (Haute-Saône, F) (© B. Armbruster; Musée d'Archéologie Nationale, Saint-Germain-en-Laye, F)

Early Iron Age torcs mostly appear in luxury male grave mounds, which are concentrated in Eastern France, Western Switzerland and South-West Germany (Milcent et al. 2018, Fig. 31). At this point, only 11 of the 18 torcs were analysed in the frame of the earlier French-German project “West Hallstatt Gold”. Even this small number indicates that they were most

probably manufactured of natural alluvial gold alloys with variable contents of silver and copper, ranging from 5 to 29% Ag and 0.1 to 1.5% Cu (Fig. 10). Trace elements like tin and/or platinum-group elements have been determined in the metal. Those elements are commonly accepted indicators for the use of alluvial gold as raw material (Hartmann 1970).

While most of the objects show a very similar composition between 5-11% Ag and 0.1-0.6% Cu, two torcs show silver concentrations exceeding 15% Ag (Stuttgart-Bad Cannstatt grave 1 and Kappel-Grafenhausen, both Baden-Württemberg, D). This huge spread in the silver concentration indicates the use of different sources of alluvial gold during the Hallstatt period.

**Complex morphologies from Ha D3 to La Tène A torcs (5<sup>th</sup> – beginning of the 4<sup>th</sup> century BC)**

In Ha D3 the typological spectrum of torcs broadens. There are still neck rings that resemble those made in Ha D2, such as one example from Herberlingen-Hundersingen “Gießübel-Talhau” (Baden-Württemberg, D), tumulus 1, secondary burial 2, and from grave 2 at Mercey (Haute-Saône, F), but these are made of smooth, undecorated sheet metal. Construction forms like the use of the spinning lathe or geometric ornamentation have disappeared. Most common at that period are torcs, which remain in a closed annular shape,

while featuring a technological novelty: a bi-metallic construction consisting of a copper/bronze or iron core covered with a thin gold sheet like Châtonnaye, Düdingen (both Fribourg, CH), Hermrigen (Bern, CH), Ihringen “Nachtwaid”, Rottenburg-Baisingen (both Baden-Württemberg, D) or Wallerfangen (Saarland, D). The bi-metallic Ha D3 torcs have a rough north-south distribution, which extends from western Switzerland via the Rhine to the Saarland. In one case, this bi-metallic construction type has been slightly modified in LT A, as the torc from grave 1 at Bad Dürkheim (Rhineland-Palatinate, D) is filled with lead.

The torc from the female grave from Vix (Côte-d’Or, F) in Central Eastern France reveals another line of development during Ha D3. It has an open construction with pear-shaped terminals and with a mass of 480 g. This innovative torc variant with pear-shaped decorative terminals and composed of various individual elements joined by soldering continues in LT A such as on the torcs from Lavau (Aube, F) or the one from Reinheim (Saarland, D; Fig. 4b).

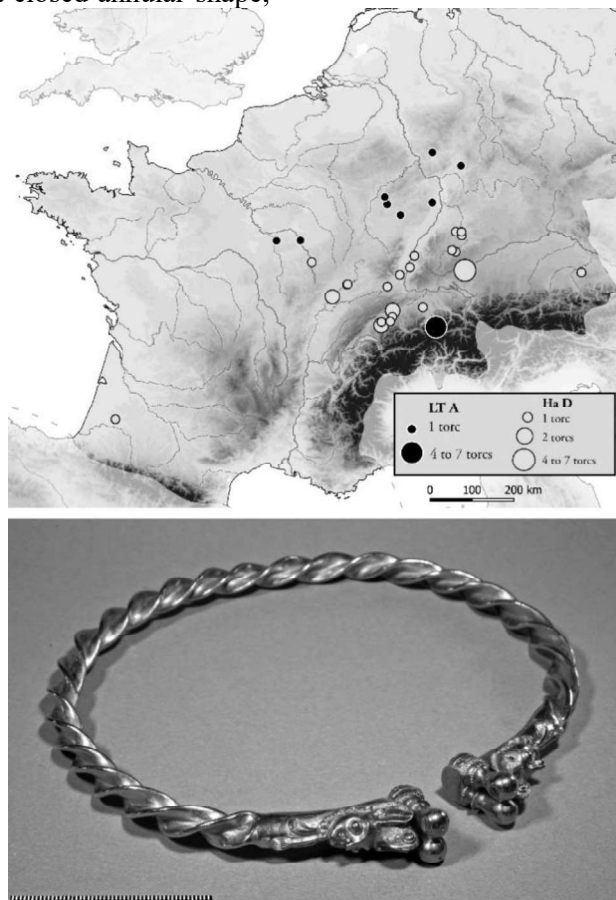


Fig. 4: a) Distribution map of Ha D3-LT A torcs (© M. Nordez)  
 b) Torc from Reinheim (Saarland, D) (© B. Armbruster; Museum für Vor- und Frühgeschichte, Saarbrücken, D).

Compared to the previous period, the LT A torcs are open or have a locking system (the latter case concerns 8 out of the 12 recorded), narrower (average diameter around 144 mm), and at the same time they gain in mass (between 110 and 580 g, for an average mass of 223 g). During LT A, the first sophisticated closing systems arise with the torc from the male grave 1 of the Glauberg (Hessen, D; Will 2018, 157, Fig. 35-36). A combination on the same object of lost wax casting for some parts and plastic shaping for other parts occurs since Ha D3. In LT A the main distribution shifts to the former northern periphery, especially the Middle Rhine area (Fig. 4a; Milcent et al. 2018, Fig. 36). Torcs are now mainly found in female graves, with few exceptions as in Glauberg, maybe Besseringen (Saarland, D) and Lavau (Aube, F); at the end of the period or during a transitional phase to LT B, comparable torcs are deposited in hoard context, as in Erstfeld (Uri, CH) where an assemblage of 4 torcs and 3 bracelets were discovered.

The chemical data set for LT A torcs is unfortunately very small. Only three objects have been analysed so far. Silver contents vary from 2-10% and are thus very comparable to the gold of the late Hallstatt period torcs, even though silver contents seem to decrease while copper contents tend to be slightly higher (Fig. 10). However, the general alloy and trace element compositions indicate again the use of alluvial natural gold alloys. Remarkable is the low silver content of the torc from Reinheim with only 2%, because larger amounts of gold with less than 5% silver are very rare in natural gold deposits. Torcs produced from gold alloys with more than 10% Ag, as known from the previous period, have not been found yet in LT A.

#### **The Waldalgesheim or vegetal style (4<sup>th</sup> – beginning of the 3<sup>rd</sup> century BC)**

A new change is seen in the morphology and decoration of the torcs from LT B: the complex closing systems of some LT A productions are becoming rarer in favour of open-shaped torcs, with discoid non-functional buffers as terminals and slightly increasing shaft diameters towards those buffers. They are mainly massive, heavy (between 53 and 392 g, with an average of 191 g) and their morphology is very similar to contemporary copper alloy torcs. The average

diameter is larger than in the previous period (156 mm). LT B1 also corresponds to the development of the Waldalgesheim or the vegetal style, as is illustrated by the torc from the eponymous archaeological site (Rhineland-Palatinate, D; Fig. 5b) – the grave of a woman. In addition to this piece, only two other reliable finds are known from our area of research: a fragment from “Rheinhessen” (Rhineland-Palatinate, D), between Mainz and Worms, and another piece from Meung-sur-Loire (Loiret, F), plus a fourth specimen from Belgium, which however originates from the art market and which might be a forgery. In addition to these examples made entirely of gold, there are also four bronze torcs with small decorative elements made of thin gold sheet. But this does not mean that the custom of wearing gold torcs went out of fashion - on the contrary: as in the transition from the Hallstatt to the La Tène period, LT B again shows the phenomenon that the distribution of gold torcs has mainly shifted to the area of the former peripheries (Fig. 5a). Gold torcs now also appear outside of our research area, in England, northern Italy and Austria. These torcs impressively document the La Tène material culture expansion during that time. Their manufacture is mainly based on lost wax casting of a preliminary product with most detailed relief, and finished by chasing the massive gold. Currently we have to rely mainly on literature data concerning the chemical composition of torcs dating to LT B, since our own database does not allow any conclusions at this time as it contains only results of the torc fragment from “Rheinhessen”. However, referring to published results, the chemical composition of the Waldalgesheim torc (around 4% Ag and 0.5% Cu; Hartmann 1978) again indicates the use of natural alluvial gold alloys with comparatively low silver contents. Unfortunately, only surface analyses exist for the torc from Heerlen (Nord Limburg, NL; Echt et al. 2011) but the use of natural alluvial gold seems very likely as well. A trace element analysis of the unaltered metal would be necessary to confirm this. In contrast, the torc fragment from “Rheinhessen” shows elevated silver concentrations of 21%. Gold with around 20% Ag was more common during the Hallstatt period, but in comparison to the silver-rich gold from Hallstatt period, the gold alloy of the “Rheinhessen” torc fragment shows elevated platinum and palladium concentrations with up to 90 µg/g.



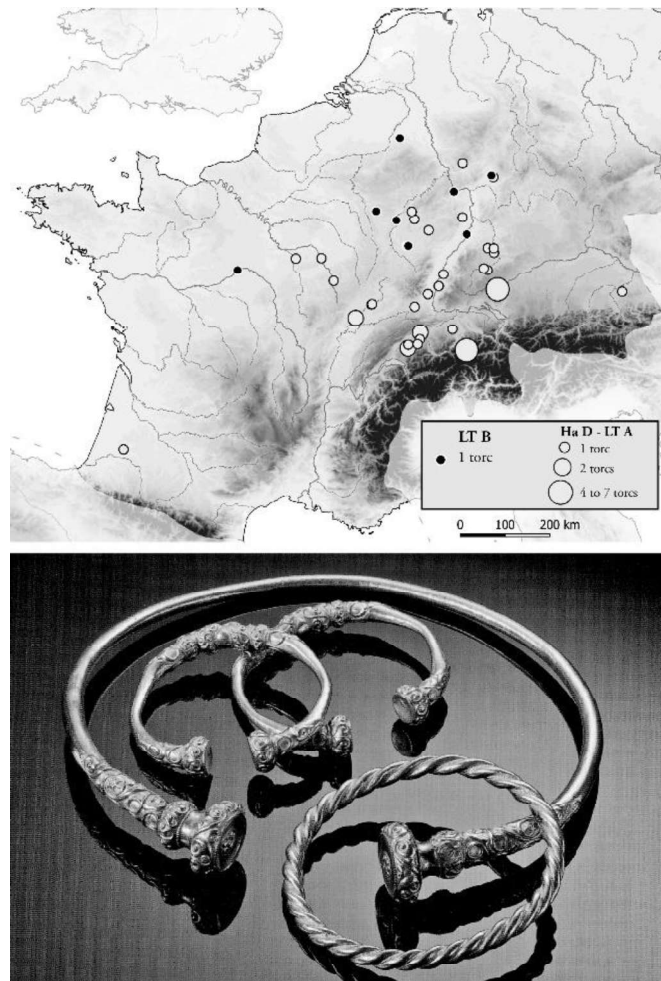


Fig. 5: a) Distribution map of LT B gold torcs and bronze torcs with gold sheet decoration (© M. Nordez)  
 b) Torc and bracelets from Waldalgesheim (Rhineland-Palatinate, D) (Farley and Hunter 2015, 69, Fig. 50)

### Plastic decoration and complex closing systems (3<sup>rd</sup> century BC)

The 3<sup>rd</sup> century BC is a turning point in gold processing with very clear morphological and technical changes during LT B2 to LT C1. This period is consistent with the emergence of a very particular “efflorescence” plastic decoration characterized by stylized floral designs (Fig. 6b). Simultaneously, several variations of twisted torcs occur, sometimes with disc shaped terminals, sometimes combining a twisted body and sleeves or buffers bearing the “efflorescence” decoration. 10 of the 16 neck ornaments recorded for this period show a complex closing system, which is consistent with a decrease in average diameter (131 mm). The most complex fasteners consist of a system of a sophisticated keyhole shaped mortise and tenon on the front of the torc, combined with an interlocking system with dowel pin and slide on the back. There are two

distinct techniques applied for the hollow torcs with “efflorescence” decoration. One group is made by hollow lost wax casting (e.g. Fenouillet, Haute-Garonne, and Lasgraißes, Tarn, F), while the second group, which is morphologically very similar, is produced by chasing and repoussé of thin gold sheet (e.g. Civray-de-Touraine, Indre-et-Loire, or Montans, Tarn, F).

The deposition practices continue to evolve as these torcs exclusively come from hoard contexts; we cannot tell if they belonged to women or men. Again, the distribution of the hoards indicates a shift towards a former periphery, namely the Western and Southwestern fringes of the La Tène area (Fig. 6a). At about the same time, namely in LT B2 and LT C1, the first Celtic gold coins appeared in the western La Tène area, in the Upper Rhine region (Kos and Wigg 2002, 368).

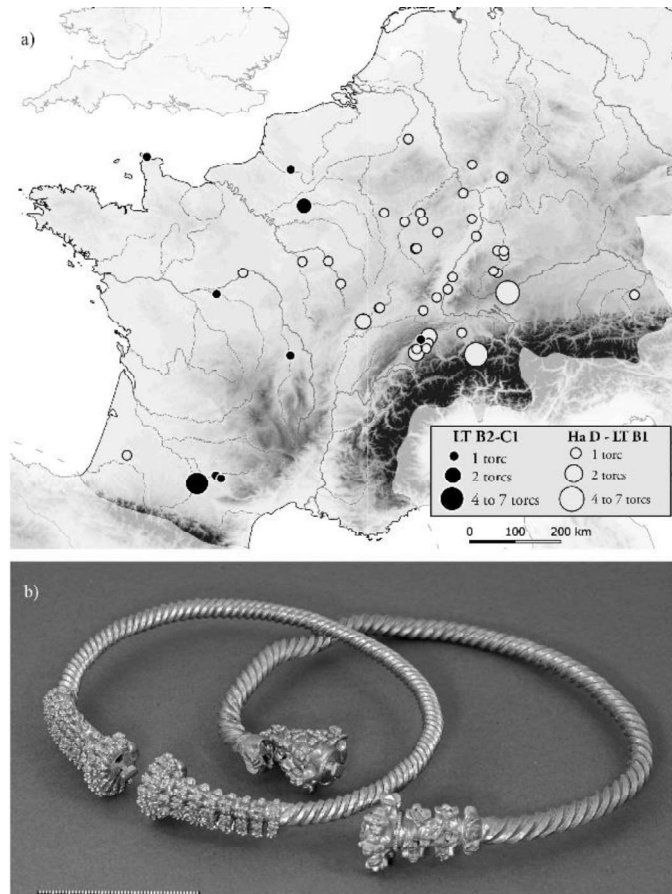


Fig. 6: a) Distribution map of LT B2-C1 gold torcs (© M. Nordez)  
 b) Torcs from Civray-de-Touraine (Indre-et-Loire, F) and Fenouillet (Haute-Garonne, F) (© B. Armbruster; Musée d'Archéologie Nationale, Saint-Germain-en-Laye, F, and Musée Saint-Raymond, Toulouse, F)

While in previous periods mainly natural gold alloys were used, a larger amount of intentionally desilvered gold seems to have been used for the production of this special type of torc. Nine of eleven analysed torcs show unusually low silver contents of 0.5-2.6% silver and 0.2-0.8% for copper with increasing contents of platinum and palladium. Normalizing the amounts of platinum to gold reveals a comparatively huge variation from 10 to 210  $\mu\text{g/g}$ . Especially  $\text{Pt/Au} > 35 \mu\text{g/g}$  occur here for the first time indicating a new source of (purified) gold. Apart from this, the two items from Soucy (Yonne, F), which have a particular morphology (possibly dating slightly later) were most likely produced from a natural gold alloy, containing around 8% silver and comparatively high amounts of copper (2-3% Cu). It should be noted that the absence of analysis on torcs from the 4<sup>th</sup> century BC makes it impossible to know how this change, which could very well be more gradual than what we perceive here and which could date back to the 4<sup>th</sup> century BC, looked like.

### **Solid torcs with discoid buffers and tubular torcs with mortise and tenon fastener (2<sup>nd</sup> century BC)**

During the following period (from the end of LT C1 to beginning of LT D1, corresponding approximately to the 2<sup>nd</sup> century BC), a simplification of the torcs is visible, mainly characterised by light tubular and disc shaped buffers bearing an unpretentious clasp with pin and mortise. They are manufactured in thin sheet, with soldered and mechanical joints. There are some exceptions like the very heavy torc from Tayac near Bordeaux (Gironde, F) with a solid, twisted body and big buffers. 11 torcs are recorded for this period (Fig. 7a), but it should be noted that almost all were found incomplete and/or fragmented: only two are complete and buried intact.

A continuity with the 3<sup>rd</sup> century BC deposition practices is obvious: torcs still appear in hoards, but from this period onwards, they are frequently broken and associated with gold coins. Thus, a close connection appears between

torcs and coins, even if the reverse is not necessarily true (most gold coin hoards do not contain associated ornaments). The hoards from Beringen (Limburg, B; Fig. 7b) and Tayac are significant examples of this particular way of deposition. This association is likewise evident from a special coin type, named “rainbow cups”, where one minted motif depicts several coins surrounded by an opened torc. This recurrent association depicted on these coins reflects the presumed particular role of the torcs.

With the changes in style and manufacturing techniques, there are also changes in the gold

alloys used. Most torcs have increased silver contents of up to 27%. With the silver contents, increased copper contents of up to 8% can also be observed. The copper was certainly intentionally added here. These changes in the depositional practice (fragmentation, association with coins), the comparatively simple production technique compared to the torcs of the previous period as well as the significant reduction in the fineness of the gold clearly reflect changes in the symbolic character of the torcs.

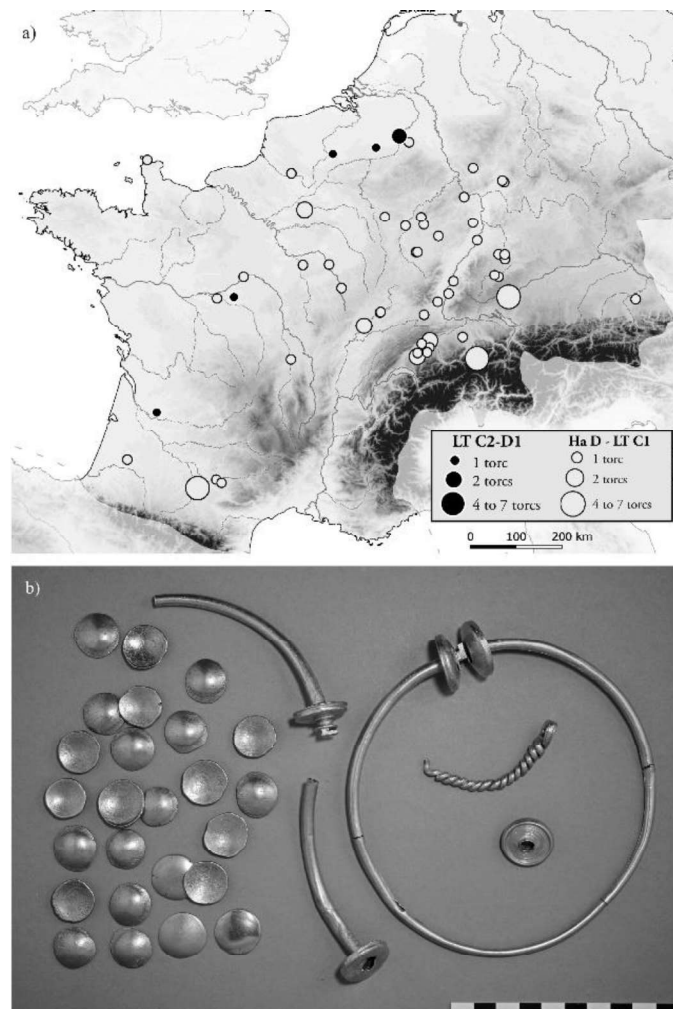


Fig. 7: Distribution map of LT C2- D1 gold torcs (© M. Nordez)  
 b) The Beringen hoard (Limburg, B) (© B. Armbruster; Gallo-Romeins Museum, Tongeren, B).

**Tubular torcs with big non-functional buffers (1<sup>st</sup> century BC)**

Finally, the 25 recorded torcs of the whole LT D period follow the trend announced in the previous period by the morphology of Beringen, characterised by a tubular body and disc-shaped

buffers with a central clasp in between. Most LT D specimens are much larger with two big wheel shaped buffers, usually assembled and hence non-functional (e.g. Le Câtillon II, Jersey, UK; Warlincourt, Nord, F). The hollow round-sectioned body often shows a filling (wax or pitch?) and an iron core. This type of

torc has double clasps: one at the rear and the other in the front between one disc and the tube. In some cases, it might have been located on the rear part of the torc, which is often missing (e.g. Mailly-le-Camp, Aube, F).

The manufacturing of the hollow body and buffers implies mainly the hammering of thin gold sheet and the soldering of the tube. The buffers are fixed by soldering or by mechanical joints. These large tubular neck ornaments also abandon the former mortise and tenon clasp. Some of them are decorated with chased patterns, as well as with soldered filigree and granulation (e.g. Mailly-le-Camp, F). The average mass of the objects does not give any information, as most objects are filled with other materials (wax and an iron core) and gold is therefore only a small part of these torcs. Indeed, if they have a very massive and heavy appearance, gold is only present on the visible parts. In continuity with LT C2, there is a decrease in the quantity of gold invested in torc

fabrication. However, the significant fragmentation observed on the torcs of LT C2-D1 hoards is less significant in the last decades of the Iron Age.

Torcs are mostly found in hoards, sometimes linked to a sanctuary or other ritual places, and often in association with coins (Jersey; Saint-Louis, Haut-Rhin, F; Fig. 8b). The geographical shift mentioned above continues towards North-Western Europe (Fig. 8a). The torcs from Saint-Louis (Fig. 8b) and Mailly-le-Camp were produced from comparatively silver-poor gold (3-5% Ag) with low copper contents (1-2% Cu). Although the use of purified gold is not as evident as in the plastically decorated torcs from LT B2-C1. However, the use of gold with low amounts of silver should not be generalized as only a few torcs of this period have been investigated within the project so far. Further analysis will show to what extent these statements have general validity.

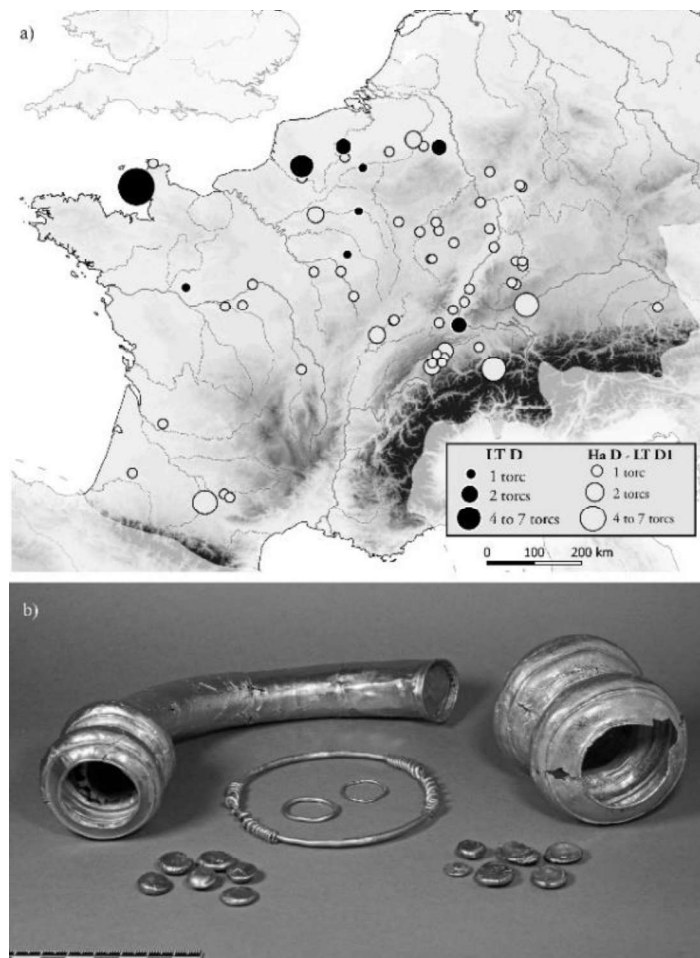


Fig. 8: a) Distribution map of LT D gold torcs (© M. Nordez) b) The hoard from Saint-Louis (Haut-Rhin, F) (© B. Armbruster; Musée d'Archéologie Nationale, Saint-Germain-en-Laye, F)



Fig. 3b



Fig. 4b



Fig. 5b



Fig. 6b



Fig. 7b



Fig. 8b

Fig. 9.: Coloured images of the examined torcs.

## Chemical composition of the torcs

From the previous section, it became evident that the chronological development is linked to changes in the geographical distribution, the type of deposition, the production technique and also the chemical composition of the torcs.

At the end of the Early Iron Age (Ha D2-Ha D3) mainly silver-rich natural gold alloys were used for closed sheet-metal torcs with geometric

decorations produced on a spinning-lathe. In the transition from Ha D3 to LT A, torcs start to become decorated with complex morphologies and the silver content continues to decrease (Fig. 10). Possibly, other natural gold sources of higher fineness became available. In general, the Early Iron Age (Ha D2 to LT A) is characterized by low Pt- and Pd-contents (3-26  $\mu\text{g/g}$  Pt and 6  $\mu\text{g/g}$  maximum Pd) (Blet-Lemarquand and Armbruster forthcoming).

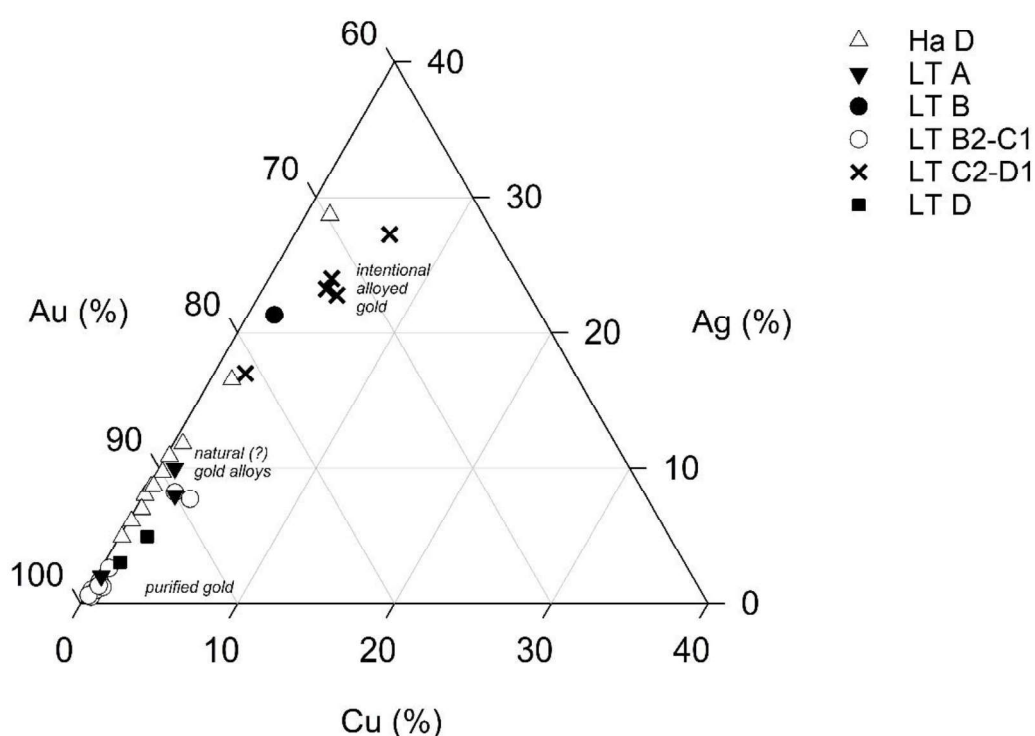


Fig. 10: Ternary diagram of gold (%), silver (%) and copper (%) of 34 torcs dating from Ha D2 to LT D2 (© N. Lockhoff). Data: ANR-DFG "West Hallstatt gold" (B. Gratuze, V. Leusch), ANR-DFG "Celtic Gold" (M. Blet-Lemarquand, N. Lockhoff), S. Nieto-Pelletier's analysis [Urville-Nacqueville], Barrandon & Sarthre 1999 [Tayac]. LA-ICP-MS analyses, except for the Tayac torc (Proton Activation Analysis).

Once again, there is a lack of data to characterize the metal stock used for the manufacture of torcs in the 4<sup>th</sup> century BC.

This is why the composition of the torcs of the 3<sup>rd</sup> century BC appears as a significant change: mainly distributed in Southwestern France, they have very high gold contents (up to 99%) that clearly indicates that larger amounts of purified

(intentionally desilvered) gold became available then for the production of gold ornaments. Nevertheless, the high contents of Pt (Pt/Au > 35  $\mu\text{g/g}$ , see Fig. 11) of the torcs of the 3<sup>rd</sup> century BC are in line with one or several new available gold sources. Indeed, even for pure gold objects from previous periods, these contents are different, indicating a change in gold supply.

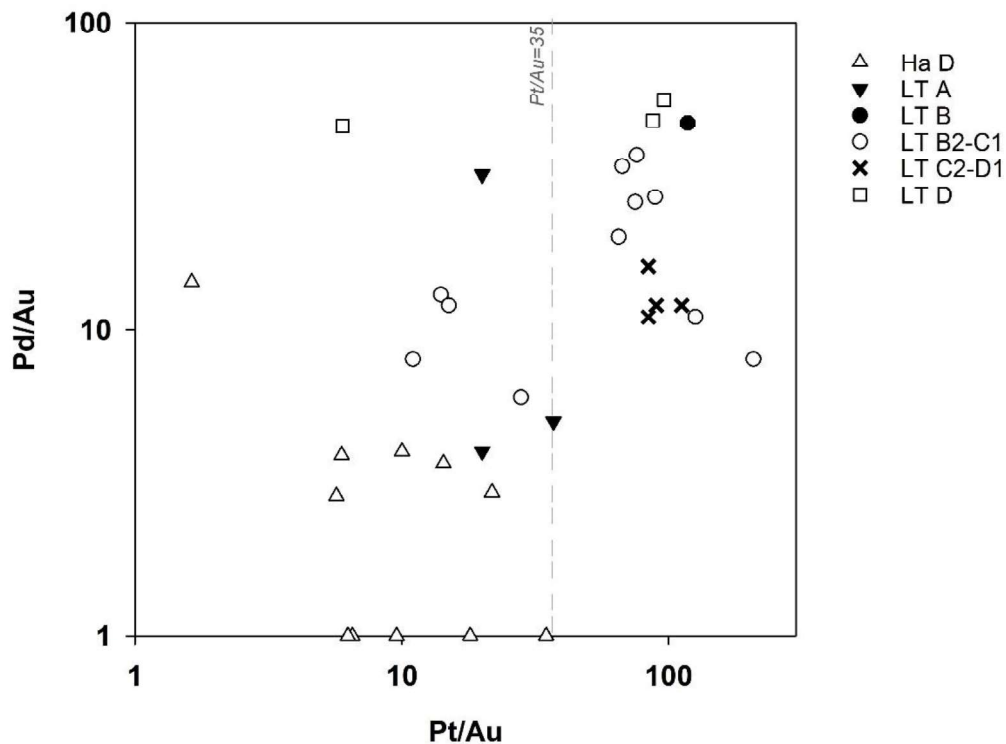


Fig. 11: Scatterplot of platinum and palladium both normalized to gold for 33 torcs from Germany, France and Belgium dating from Ha D2 to LT D (© N. Lockhoff). For few objects of Ha D palladium contents were below the limit of detection ( $1\mu\text{g/g}$ ), those samples are plotted as Pd/Au=1 on the y-axis. Data: ANR-DFG "West Hallstatt gold" (B. Gratuze, V. Leusch; Dubreucq et al. 2018, 159; Schorer et al. 2018), ANR-DFG "Celtic Gold" (M. Blet-Lemarquand, N. Lockhoff).

The 2<sup>nd</sup> century BC corresponds to a period during which gold was intentionally alloyed with copper and possibly also with silver. This intentional "dilution", while keeping the colour of the alloy still golden, meant that in the end even less gold was used for production. This "mixing" is also known for coins, with which these jewels are frequently buried from the 2<sup>nd</sup> century BC onwards.

The analyses carried out so far have revealed several possibilities. Within the same hoard, gold ornaments and coins may have similar compositions, whether major or trace elements (Pt and Pd). This is the case in Beringen or Sinsle-Noble hoards, for example: the objects were made with a stock of gold, which shows a similar chemical pattern (Nordez et al. forthcoming; Sillon 2014). However, in other cases, coins and ornaments do not have the same composition, such as in the Tayac hoard (Barrandon and Sarthre, 1999). In the latter case, these differences can be explained, at least

in part, by the fact that the coins come from different issuing regions, sometimes very distant from each other.

There are still some gaps to be closed as the project progresses. This concerns especially torcs of the Waldalgesheim style as well as torcs of the 1<sup>st</sup> century BC. Before general conclusions can be drawn, the outlined development of the changes in the alloy composition has to be compared with other contemporary gold objects.

### Conclusion

This diachronic approach over six centuries has made it possible to discern very precisely the evolutions in the morphology, technology and deposition practices of torcs from late West Hallstatt until the end of the La Tène period, and links can be established with variations in chemical composition.

While native gold seems to have been used for the manufacture of the torcs of the Early Iron Age (Ha D2 - LT A), a change could be perceived in the 3<sup>rd</sup> century BC in South-western France with the use of purified gold with different platinum and palladium patterns, indicating that new gold supply networks emerge in this area. Often this is explained by the payment of Celtic mercenaries with Greek staters, which would then be taken back to Gaul and remelted. At the current state of research, it is not possible to validate or dismiss this hypothesis by chemical data. As already shown by Nieto-Pelletier and Olivier (2016), the introduction of Philip Stater II to Gaul is not the result of a single phenomenon and cannot be explained by mercenaries alone. Simultaneously, the gold mining production increases in Gaul during this period (Cauuet et al. 2018). This change in the composition of the gold also coincides with the development of the Plastic Style and with an evolution in the ways in which the torcs were deposited: whereas they were almost only discovered in the context of princely graves in the Early Iron Age, they are only found in hoards from the 3<sup>rd</sup> century BC, and sporadically from LT B onwards.

If the use of purified gold is particularly evidenced from the 3<sup>rd</sup> century BC through the study of torcs, it must be sought in other categories of objects and in torcs from the 4<sup>th</sup> century BC, a period for which we have too few analyses of Western European objects so far. However, it must be stressed that developments in gold alloys in general vary widely from region to region within the La Tène area. In Central Europe, for example, there is a general reduction of the fineness of gold in almost all finds from the beginning of stage LT B1 to LT B2a or even until the transition from LT B2/C1 (Waldhauser 1998, 101). A new change seems to be discernible with the use of alloyed gold from the 2<sup>nd</sup> century BC onwards: the purity decline in the 3<sup>rd</sup> century BC gives way to a "dilution" of the gold in the following century. The 2<sup>nd</sup> century BC corresponds to a period during which the mass of torcs decreases significantly. In comparison to early La Tène style torcs, their decoration is simplified and they occur mainly fragmented in hoards.

Finally, the trends of the 1<sup>st</sup> century BC still need to be clarified by ongoing analyses. Tubular torcs were made of thin gold sheet over an iron core and gold is only present on visible

parts. This is however another way to create apparently solid gold objects without large material consumption of gold. One possible explanation might be that the role of torcs as a value storage device had been steadily lost to coins. At that time, torcs probably had more a symbolic and social function within society, and less an economic one.

The gold working techniques develop and vary according to the desired morphology and decoration. The goldsmiths' workshops were well equipped and the artisans skilled in a wide range of manufacturing processes: ingot, solid and hollow lost wax casting, plastic-shaping techniques for forming, hammering, bending, twisting and chased ornamentation, decoration techniques filigree and granulation, as well as joining techniques such as soldering and casting on, and mechanical joints made by crimping.

Although we must remain cautious about interpreting these evolutions, the results presented certainly will allow us, in the long term, to think in terms of social, economic, political and cultural transformations.

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