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on traditional Skills and Handicrafts
in Archaeological Open-Air Museums in Europe

Edited by Rüdiger Kelm

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SMITHS AND SMITHING IN BRONZE AGE “TERRAMARE”

by Cristiano Iaia, Rome

Abstract

The project ‘Smiths in Bronze Age Europe’ is based on an interdisciplinary collaboration between archaeologists with various specialization and expert craftsmen engaged in replicating bronze artefacts. Its main purpose is that of a detailed reconstruction of the tools and work procedures of the metallurgists of the Terramare (1650–1125 B. C.), an important Bronze Age culture of northern Italy. The research has focused on investigating aspects of secondary working of bronze artefacts that are usually underrated in scholarly discourses and experiments, particularly the long post-casting processes. Through the integration of archaeological data and experimental tests it has been sought to verify if there is reason to assume a division into different levels of competence of the metal craftsmen in the context in question.

Introduction

“Smiths in Bronze Age Europe” is a subtopic of the OpenArch-Work Package 4 (WP 4) – Dialogue with skills dealt with the Museo Civico Archeologico Etnologico of Modena, Italy (Ilaria Pulini, Cristiana Zanasi), in partnership with the Sapienza University of Rome (Andrea Cardarelli, Cristiano Iaia). It is planned as a manifold endeavour which includes various lines of inquiry in the frame of the Open Arch-program (a first synthesis: IAIA et al. in press).

The project is inspired by the intention to foster collaboration and discussion between people with different backgrounds and expertise: experts of Bronze Age cultures, archaeologists engaged in experimental practices on a voluntary basis, craftsmen specifically interested in the Bronze Age, archaeometrists and geologists. This originated from the long experience of the archaeological museum in Modena and the Montale Open-Air Museum in the general field of experimental work for the Bronze Age, which goes back to the late 1990s (BERNABO BREA et al. 1997). Main goal is to develop methodology and practices for dealing with knowledge, tools and skills involved in the process of manufacturing Bronze Age-type metallic artefacts, in northern Italy but with a Europe-wide perspective. At the same time we have been trying to improve skills and awareness of the people – both craftsmen and archaeologists – involved in replications of prehistoric objects, by devoting a particular attention to accurate protocols and recording procedures. Core of the project is the Terramare culture, which developed between the southern Po Plain and the northern Apennines (Northern Italy) during the Middle and Recent Bronze Age (ca. 1650–1150/1125 BC). The Terramare culture represents

one of the most significant manifestations of the European Bronze Age, in terms of the importance and abundance of archaeological remains, as well as for the high quality of the available documentation. ‘Terramare’ can be defined as mainly quadrangular settlements a few hectares wide located in lowland areas, surrounded by an embankment and a ditch collecting water from a nearby river. These villages reached a considerable size (up to ca 20 hectares) and high population density especially between the advanced Middle Bronze Age and the Recent Bronze Age, about 1400–1125 BC. Collective management of settlements and landscapes through well-organized farming activities, huge communal works (embankments, ditches, drainage channels, wells, warehouses etc.), as well as some aspects of the funerary ideology, are considered indication of the strong cohesive character of these communities (CREMASCHI 1997; CARDARELLI 2010, 453; CREMASCHI u. PIZZI 2011). Indeed, their territorial and socio-political organization was subjected to a continuous transformation, which in particular led to an increasing demographic pressure and to the development of a clearly recognizable hierarchical organisation towards the end of their historical cycle, around 1300–1125 BC (CARDARELLI 1997). For a better comprehension of this topic, we have enlarged our perspective to areas nearby, such as the *Palafitte* or lake-dwellings of the southern Lake Garda, as well as making comparative surveys on the Bronze Age of continental Europe.

The project’s team started by posing some general questions that have remained on the background:

- Taking into account the available archaeological data in Italy (and Europe), were the Terramare smiths a homogeneous, or a multilayered category, depending on knowledge, skill, specialization degree and social status?
- And if a division of smiths into different levels actually existed, is there evidence that it served specific needs and purposes of the communities for which (and within which) it operated?

Emphasis has been put on the degrees and internal subdivisions of metalwork, taking for granted that we have to do with ‘specialist work’, though not necessarily with full-time professionals (compare the debate started since ROWLANDS 1971, 212, updated in KUIJPERS 2008, 30).

Ideas and questions put forward at the beginnings have been gradually growing. In 2011 we started to examine the Terramare archaeological record and tried to relate it with experimental experiences carried out by members of the team. In some intense brainstorming that involved craftsmen, archaeologists working at the Montale open air Museum, archaeometrists and earth science experts, it has been realized that some steps of the ‘operative chain’ of metallurgical processes in the Bronze Age were largely under-represented in mainstream reconstructions; then, we planned a strategy to investigate these steps joining together archaeological research and experiments, in order to improve their understanding and, eventually, the re-enacting of metallurgical practices to the wider public. A first step of the project was completed in April 2012, when the ‘Smiths in Bronze Age Europe’ workshop took place in Montale and Modena (<http://openarch.eu/work->

packages/activities/smiths-bronze-age-europe-workshop-modena-and-montale-rangone-mo-it).

Within the Terramare culture a clear spatial and operational distinction between the 'primary production' of metals (ore extraction, smelting), and the manufacturing of objects, or 'secondary production' emerges. The latter seems to have taken place predominantly in the main population centres (the Terramare villages), while the former was certainly taken out in mountainous areas such as the Alps (MARZATICO 2011) or the Appennines. Meanwhile, mineralogical and chemical analyses are investigating the possibility of an exploitation of copper ores from the Apennine chain by the Terramare smiths (researches in progress by F. Scacchetti: unpublished degree dissertation, University of Ferrara; advisors prof. M. Mazzuchelli and prof. A. Cardarelli), while no evidence of smelting whatsoever occurs in local settlements. Thus a first labour division between different categories of workers – *miners* and *smelters* on one side, *smiths* on the other – has been defined this way; however the problem persists of a better identification and articulation, in terms of professional ability and social role, of the vast category of smiths who manufactured objects for the local communities. Unfortunately, evidence for 'metalworkers burials' of the bronze age that might clarify these aspects is totally lacking in Italy, while the situation is different in East-Central Europe (e. g. BARTELHEIM 2009; NESSEL 2012) and Spain (BRANDHERM 2010). Hence the only way to tackle this issue has been to carry out surveys of the rare productive infrastructures known so far in the Terramare and of the smith's tools, with particular regard to those used within casting and post-casting procedures. This fits well the idea that tools are the features that represent better the craftsman as a social subject (FREGNI 2014, 15), beside the outcome of crafts (the artefacts), but possibly in a more direct way.

Reconstructing the smith's toolkit: 1. Casting

The reconstruction of the smith's toolkit is a crucial issue in several Bronze Age studies in Europe (e. g. PERNOT 1998; KUIJPERS 2008). Nevertheless, many questions remain unanswered, especially when handbook reconstructions and stereotypes are compared with the detailed archaeological record of specific areas like the one under consideration. Thus, of great importance for the progress of the project has been to critically compare different, and sometimes divergent points of view on this subject matter.

As a matter of fact, most Terramare settlements have provided implements for casting and post-casting processes, sometimes in considerable quantities (LEHOERFFL 1992; BERNABO BREA et al. 1997, 390–404; 577–586; BIANCHI 2010, fig. 1). They are mainly represented by crucibles, blow-pipes, tuyeres (fig. 1. A, B), stone moulds (Fig. 1. C, D) and various lithic tools. Melting and casting activities *in situ* are testified to by pits with traces of firing and related tools (especially crucibles and blow-pipes) that are found in a handful of Terramare villages: remarkable are those carefully excavated at Castellaro del Vho, Montale and

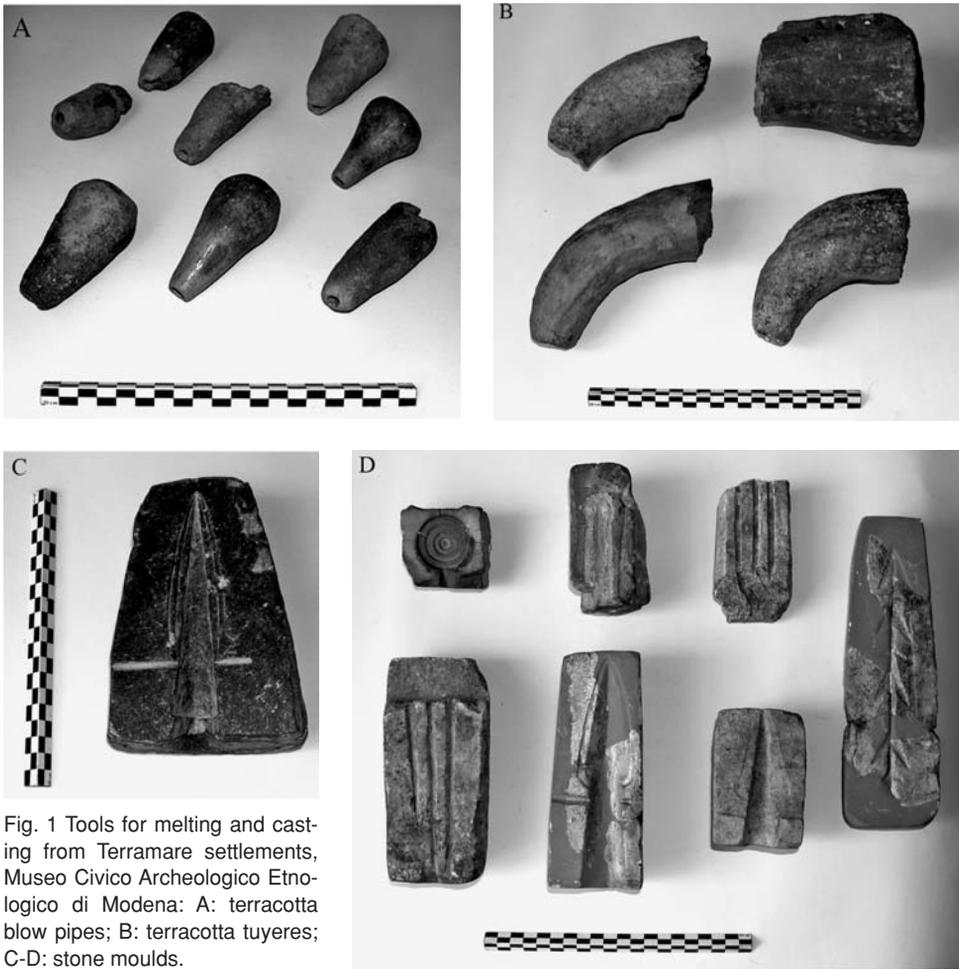


Fig. 1 Tools for melting and casting from Terramare settlements, Museo Civico Archeologico Etnologico di Modena: A: terracotta blow pipes; B: terracotta tuyeres; C-D: stone moulds.

Beneceto (FRONTINI 2001; CARDARELLI 2004, 45; BIANCHI 2010). Actually, the whole evidence suggests that casting practices were far from circumscribed: fieldwork carried out by members of the team (CAVAZZUTI et al. in press) has proposed that their apparent rarity is due to inherent problems of preservation and/or visibility of humble categories of archaeological contexts, namely small pits and provisional furnaces, and to research history. Moreover the diffusion of metalworking throughout the Terramare is strongly suggested by the widespread co-occurrence of bronze objects of local production, including a wide range of working tools, weapons and ornaments, whose variety and technological quality improved decisively between Middle Bronze and Recent Bronze Age (CARANCINI 1991–92; 1997).

While terracotta moulds are rare in this area (as generally in Italian Bronze Age complexes), several dozens of bivalve moulds made from stone (e. g. Fig. 1. C, D) have been recovered in the Terramare villages (LEHOERFF 1992). Their number is constantly growing. In the framework of this project Monia Barbieri, in col-



Fig. 2: Sand casting of a bronze sword. Experiment by C. Cavazzuti, L. Pellegrini, F. Scacchetti.

laboration with prof. Stefano Lugli of the Modena and Reggio Emilia University, has examined from the technical and petrographic points of view about 96 exemplars of stone moulds from Terramare villages of the Modena and Reggio Emilia districts (BARBIERI u. LUGLI 2012). This investigation has proceeded in parallel with the experimental replication of stone moulds conducted by members of the Montale team

(BARBIERI u. CAVAZZUTI 2014). This activity has aimed at evaluating working-times and levels of skill needed for the manufacture of this class by means of reproductions of ancient tools (bronze chisels, punches, axes and stone hammers). Interestingly, it resulted that carving a mould needed about 1–2 working days on average and a certain care; this suggests that common stone moulds could be manufactured by medium level metalworkers, endowed with a good empirical knowledge, though not necessarily with special skills. On the other hand, those made of fine-grained rock, such as ophiolite (e. g. Fig. 1. C), were clearly of more difficult fabrication and implied a superior ability.

In spite of the numerous traces of metalworking and the considerable scale of the whole bronze production in the Terramare, evidence for casting remains comparatively rare. For example, notwithstanding the great number of swords recovered in Bronze Age Italy, “permanent” moulds (made out of stone or ceramic) for producing the long slashing swords of the Late Bronze Age are nearly absent. The only exception so far known in northern Italy is the multiple stone mould for making swords of the Erbenheim type from Piverone (Turin), which dates to a later period, the Final Bronze Age (BIANCO PERONI 1970, tav. 75). An explanation for this phenomenon could be the use of casting procedures that did not leave clear archaeological evidence. One of these might have been sand casting, a method well known in modern times, whose actual existence in the later prehistory is admitted by several authors (e. g. GOLDMANN 1981; CARANCINI 1991–92; OTTAWAY u. SIENEL 1998). Ongoing experimental tests carried out by Claudio Cavazzuti, Luca Pellegrini and Federico Scacchetti at Montale aimed at casting bronze swords through this technique; they have had a good response (PELLEGRINI u. SCACCHETTI 2013). The casting process consisted in preparing a wood model of the sword that was subsequently inserted in a wood box, containing also specific fine sand from the river Po (fig. 2). In comparison to casting in stone moulds this procedure had several advantages: a greater quickness of execution; the possibility of avoiding wasting of metal and thermal shocks of the mould; a greater precision in obtaining the planned details in artefacts that did not need long finishing processes (for example some ornaments, like pendants). In any case, as metallographic analyses has demonstrated that Bronze Age swords

were frequently subjected to long cycles of annealing/hammering and polishing (ANGELINI 2005, 522–523; MÖDLINGER 2011), scale and diffusion of this technique is still under scrutiny.

Reconstructing the smith's toolkit: 2. Post-casting

Another major focus of the project has been to throw light on the long post-casting procedures that are usually less investigated and hardly represented in performances and experimental activities: they include polishing and grinding, shaping and refining by cold and hot working, and the decoration of surfaces. Cristiano laia is specifically dealing with this research line (further funding has been provided by Sapienza University of Rome in 2013). He has collected a data-base of implements presumably linked to these processes, carrying out a critical review of the major archaeological contexts including them. Dataset and general issues are being compared with the various results of the experimental practices within the “Smiths in Bronze Age Europe” project (for the experiments conducted by M. and M. Binggeli see the following section).

One first issue that arises is the shortage in Early to Recent Bronze Age northern Italy of bronze tools that can be clearly connected to metalworking. Bronze percussion tools, both of the ‘active’ (e.g. hammers) and ‘passive’ categories (e.g. anvils) are very rare findings. Isolated specimens of bronze hammers come from areas north of the river Po, and only rarely can be dated to periods preceding the final stages of the Terramare culture, about 1300–1125 B. C.: it is possible to quote an example of the socketed form from the *terramara* of Finilone Valle (Gazzo Veronese, VE), presumably dating to the Middle Bronze Age (SALZANI 1996, fig. 23.7), and another one from Castello del Tartaro (FASANI 1984, 584, n. 9), but this is all we know at the moment. On the contrary, their occurrence increased in the subsequent period, the Final Bronze Age and the Early Iron Age (1150–700 B. C.), as documented for example in the large ‘craft centre’ of Frattesina di Fratta Polesine, northeast Veneto (SALZANI 1989, fig. 2. 9, 10). Bronze anvils so far known are usually very small, and were possibly conceived for shaping elements of jew-



ellery, both made of bronze and gold. One such exemplar, from the settlement of Gorzano, is characterized by a semi-rectangular form, that recalls that of an ingot, but shows clear hammer marks on the minor faces, and two irregular concavities due to prolonged hammering besides a central ridge. It was probably used to shape small sheet objects. Another possible anvil, of a very peculiar cylindrical form, comes from the lake-side settlement of Bor di Pacengo (ASPES 2011, tav. 17, n. 9), and could be dated to the Middle Bronze Age. These two objects, made from a high tin bronze alloy, have been experimentally replicated by M. and M. Binggeli (fig. 3. A, B) and turned out to be implements suitable to the forging and refining steps.

There are two possible reasons for this shortage of bronze implements: first, as widely attested in Late Eneolithic and Early to Middle Bronze Age Europe these categories of tools should have been made mainly from stone (e. g. HUNDT 1975; DELGADO-RAACK u. RISCH 2008; FREUDENBERG 2009); second, the bronze implements, especially the hammers, were presumably massive and precious objects that could have been recast for recycling purposes. Yet, this recognition does not imply a primitive characterization of the bronze technology, since stone tools were largely employed in copper-base metallurgy by highly advanced civilizations such as the Minoans (CLARKE 2014).

Polishers and burnishers are by far the most diffuse lithic implements in Early to Recent Bronze Age settlements of northern Italy (e.g. SALZANI 1996a; CASINI 2003), but they are, however, multipurpose tools; for instance in many cases they were demonstrably used for polishing pottery surfaces. Instead, a clear relation with metals can be suggested for several grinding stones and sharpeners in light of evident use-wear traces, such as very regular and deep striations; exemplars found on a certain amount in Terramare settlements are nearly all made of sandstone, an highly abrasive material.



Fig. 4 Sandstone grooved hammerstones from the Terramara of Rastellino (Castelfranco Emilia, MO), Museo Civico Archeologico Etnologico di Modena.

Especially worth noting is the wide range in form, size and materials of the stone hammers recovered in Terramare and lake-side villages, although they have been rarely published and are poorly studied (among the exceptions: CASINI 2003). They are manufactured according to traditional Neolithic and Eneolithic techniques, or, alternatively, might have been Neolithic/ Eneolithic artefacts reused in the Bronze Age. Main forms include simple or grooved hammerstones (the groove being for hafting: fig. 4), perforated hammer-axes (often erroneously considered as Copper Age re-sidues)

and small axe-like hammers (fig. 5). Experiments within the project (see the following section) have provided a good basis for testing the functional characteristics of these tools. It has been demonstrated that some kinds of beating tools widely represented in the Terramare, in particular the so-called grooved hammerstones (e. g. MUTTI et al. 1988, fig. 70.2) do not fit in working directly metal surfaces for their rough face. They were also far less durable and efficient as compared to the green stone ones because of their material, sandstone: this causes their quick exhaustion and breakage after a short working on metal. Otherwise, grooved hammerstones could be considered more beneficial to preliminary actions, such as crushing copper, or in manufacturing stone moulds. On the contrary, as will be illustrated below an extensive use of modern replicas of green stone hammers (fig. 6. A, B, replicas by M. & M. Binggeli) along with anvils or cushion stones of the same material, has demonstrated their feasibility in a great range of technical situations, including the shaping of axes, swords and bronze vessels (compare for central Europe HUNDT 1975 and



Fig. 5: Axe-like hammers made of polished green stone, from the Terramare villages of Gorzano and Montale, Museo Civico Archeologico Etnologico di Modena.

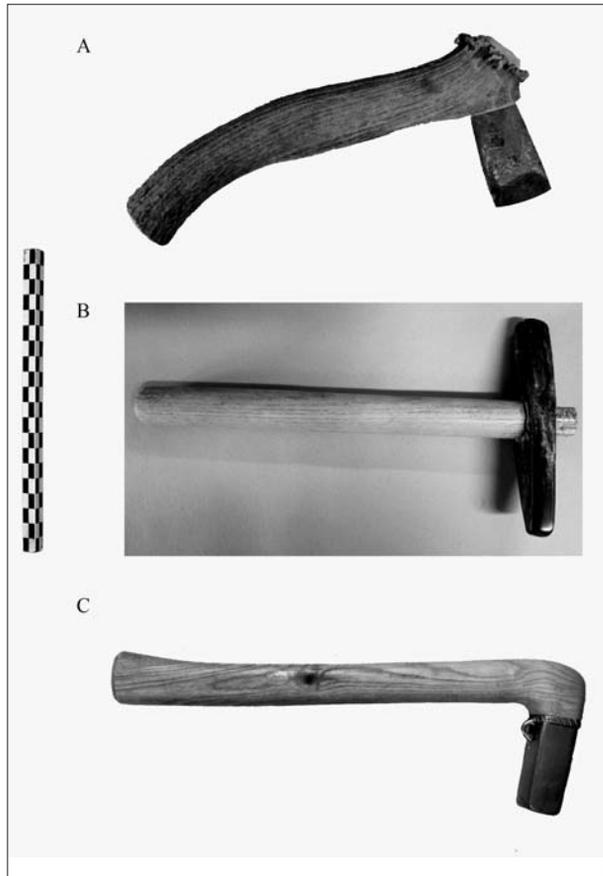


Fig. 6: Replicas of Bronze Age hafted hammers. A: green stone axe-like hammer (cfr. Fig. 5); B: green stone perforated hammer; C: bronze socketed hammer. Replications by M. & M. Binggeli.

FREUDENBERG 2009). Restrictions to their use are due to the exhaustion of the faces, that are likely to break after a certain time. This might be the reason why, during the advanced phases of the Terramare culture a new class of much more durable and effective hammers made of bronze (fig. 6. C, replica by M. & M. Binggeli) appeared in the archaeological record, in correspondence with the diffusion of new artefact categories, such as bronze vessels and armour.

2. Reproduction of Bronze Age artefacts by craftsmen

To clarify the diachronic development of bronze metallurgy in the Terramare area and to investigate the possible existence of different levels of skills and/or specialization among the artisans, a number of significant artefact forms to be replicated have been selected. We have proceeded from the hypothesis that at least two possible categories of smiths would be detectable for this period: those responsible for a limited production of utilitarian objects (simpler daggers, axes, sickles, awls) and the ones who were more devoted to the production of status symbols, namely swords and elaborate ornamental items (e.g. special pins). It seems that only in later stages made its appearance a new category of highly specialized craftsmen devoted to the production of sheet bronze vessels and parade armour. The last two categories might have corresponded to more skillful and learned craftsmen who were partly connected to emerging social levels, such as warriors of higher rank and their spouses (as attested for example in the Olmo di Nogara necropolis: SALZANI 2005).

Experimental activities have been performed by the expert craftsmen Markus and Markus Binggeli from Switzerland; they have been associated with a detailed recording protocol of each working step, including paper sheets and macro-photographs of the objects being fabricated and of the tools employed in making them. Tin and copper content of each artefact were based on the average content recorded in past chemical-physical analyses (e.g. GARAGNANI et al. 1997). Not only forms of artefacts, but also material and shapes of the tools used in the process have been inspired by the Bronze Age originals of the Terramare repertoire (see above), although doubts still remain as to the specific technical characteristics of those actually used by ancient smiths.

Since the Early Bronze Age (ca. 2200–1650 B. C.) bronze axes/adzes can be considered as representatives of the usual metallurgical production of the Po plain. Growing metallographic and archaeological evidence demonstrates that the Terramare axes were subject to long post-casting cycles that were carried out by smiths in order to form the flanges or wings for hafting, and to make the blades more regular and effective, as well as more long-lasting (GARAGNANI et al. 1997, 560 and unpublished experimental activities promoted in the 1990s by the Modena Museum). The same identical phenomenon is abundantly documented north of the Alps (KIENLIN et al. 2006). The manufacturing process needed an alternation between numerous stages of grinding, annealing and heavy cold hammering, polishing and so on. The replication of axes by M. and M. Binggeli (main



Fig. 7: Some steps of the manufacturing process of a bronze axe of Terramare type (Middle Bronze Age). Experiments by M. & M. Binggeli.

working steps in fig. 7) has been the occasion to test the material and functional properties of the wide range of stone tools already seen, including handheld hammers, both of quartzite and sandstone, a hafted serpentine hammer, a brick-shaped anvils and various sandstone grinding tools. Furthermore, it has been calculated that the whole process of manufacturing such kind of artefact by a skilled artisan may take just 17 hours.

A more sophisticated level of metal production appeared in the late EBA with the solid-hilted daggers, belonging to a class widely distributed across continental Europe (SCHWENZER 2004; DE MARINIS 2006). An outstanding specimen of this class, selected for the duplication, was recovered in the Parma area, where many Terramaras were to flourish later (DE MARINIS 1997): it belongs to the so-called 'Rhone type', which includes identical comparisons north of the Alps. This object was made joining two distinct parts, the hilt and the blade, both cast and then fixed together using elaborate rivets, and was painstakingly decorated by incision and engraving; but the more significant aspect in terms of manufacture is that to make the hollow hilt the smith needed to apply a rare technique, which involved possibly a non-reusable mould with an internal core: this is visible through the hole left by the fastening nail and is confirmed by X-ray analyses made in this occasion. All suggests that its author possessed not only a remarkable know-how, but also an individual high mastery that was presumably not transmittable just by apprenticeship. Ongoing experiments of reproduction by the Binggeli aims at testing this idea and at assessing the level of difficulty to produce it by professional craftsmen.

A series of experimental activities by the same artisans have dealt with the replicas of the most iconic among Bronze Age artefacts: the swords. We have chosen to focus on the manifest technological transformations that were introduced around 1350–1200 B. C. with the first 'cut and thrust', or slashing swords (fig. 8. A). According to recent studies, in the flange-hilted swords of the Naue II-Cetona type (BIANCO PERONI 1970, 63–65), a better resistance of the weapon could be

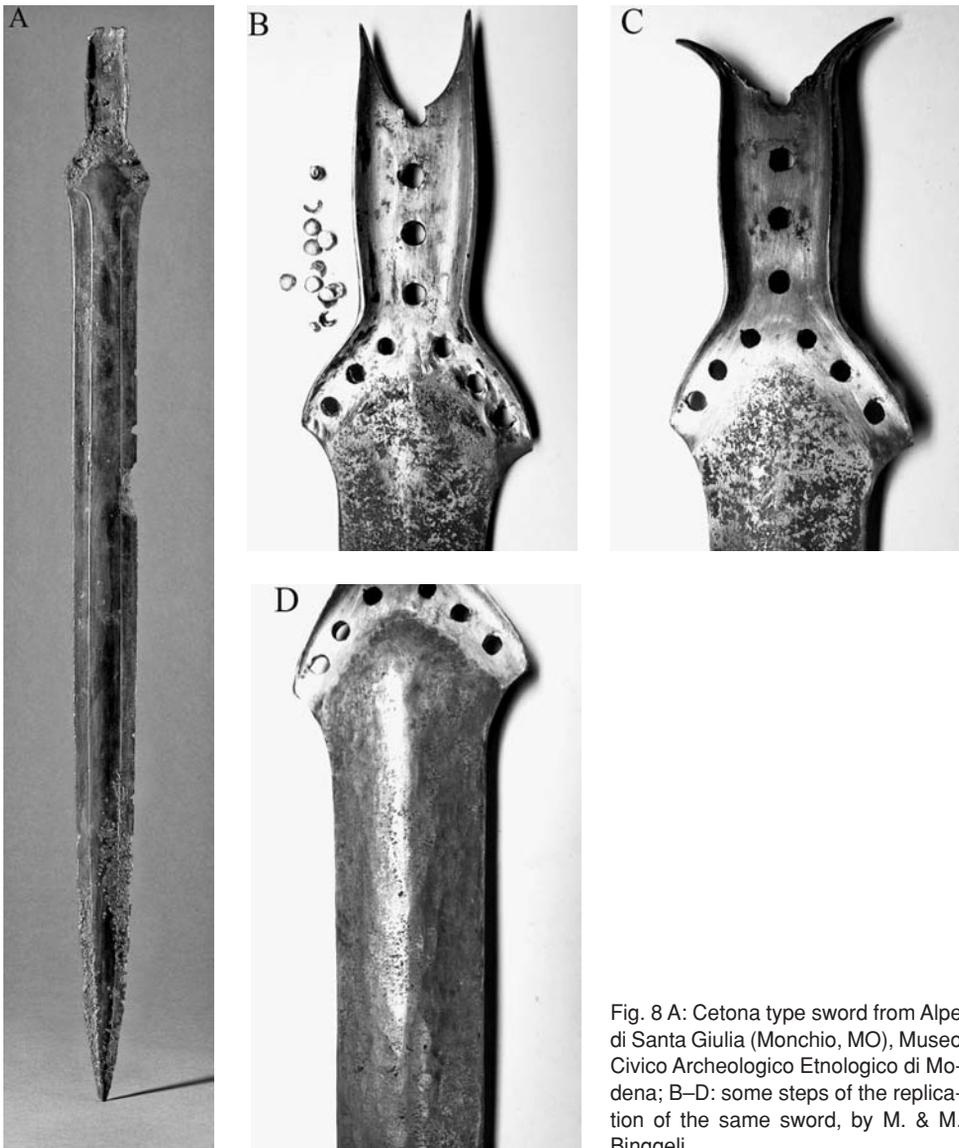


Fig. 8 A: Cetona type sword from Alpe di Santa Giulia (Monchio, MO), Museo Civico Archeologico Etnologico di Modena; B–D: some steps of the replication of the same sword, by M. & M. Binggeli.

created through the careful mixing of tin and copper (tin content 10 % on average), and especially through accurate casting and refining techniques, including a labour-intensive cold working of the edges of the blades (JUNG u. MEHOFER 2008; MÖDLINGER 2011). We are particularly interested in verifying whether the special command on the post-casting process and the definitely higher level of craftsmanship that are usually linked to these artefacts are a reality.

Main questions we intend to answer are: what kind of techniques and tools were used for producing these swords? And do these technical processes suggest special craftsmen? To clarify this point, two different specimens of the same type Cetona swords have been fabricated by the craftsmen. Experimental tests have

been carried out by means of two different toolkits, both including a range of stone and metal tools: the first one with a preponderance of stone tools (anvils, polishers, grinding stones), and specifically a green-stone perforated hammer (of the kind in fig. 6. B); the second one mainly forged with socketed bronze hammers (e. g. Fig. 6. C) that replicated originals dating to the Late Bronze Age. In particular, much effort has been required by the long actions of shaping the hilt, making holes in it (with bronze punches) and refining the blade (fig. 8. B–D). The results have suggested that the post-casting work necessary for making these weapons might have taken a very long time (over 100 hours), irrespective of whether the hammer was of stone or bronze. However, effectiveness of bronze hammers in comparison with the stone implements was much higher, also in terms of low rate of exhaustion. Chasing the channels along the blade edges ('steps' according to the Binggeli's definition) of the sword resulted an even more difficult task: a first attempt to make the decoration with metal chisels have failed, but the use of a different and unusual tool, a small stone scraper, has solved the problem, confirming how poor is our knowledge of Bronze Age metalwork technique.

Further experimental practices, still in progress, are investigating the specific issues of beaten sheet bronze, which in this area represents a totally new craft appeared between the Recent and the initial Final Bronze Age. The emergence of this production in the Terramare cultural area (e.g. fragments of armour from the Pila del Brancòn votive deposit: JANKOVITS 2004) corresponds to the 'crisis' period of the 12th century BC, when a more differentiated society was taking shape. Manufacturing these items requires a strict control of the alloy, particularly a care-

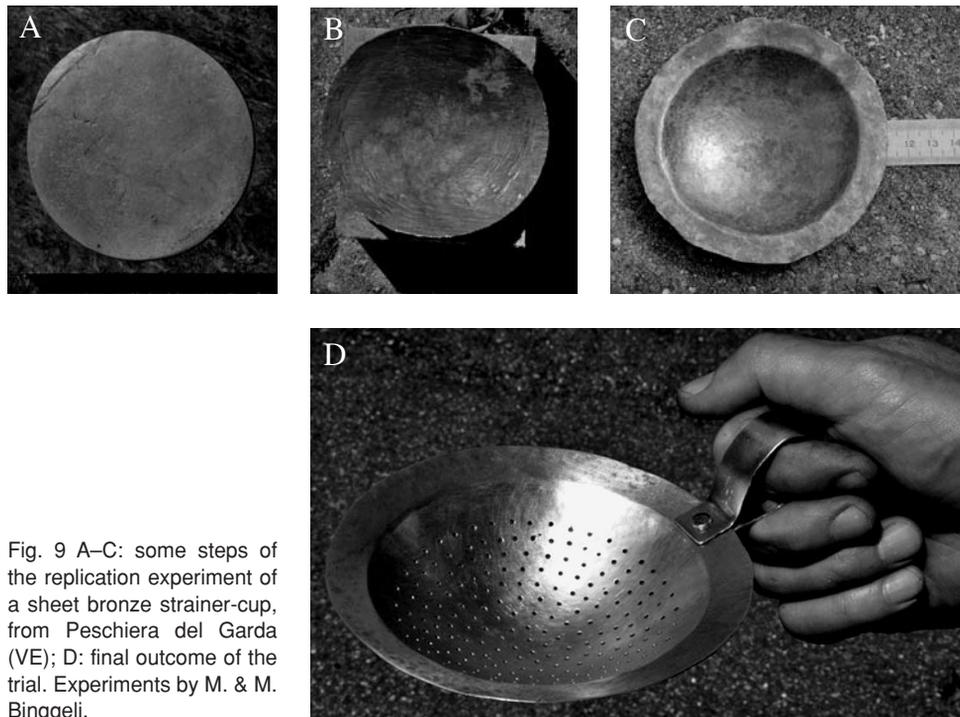


Fig. 9 A–C: some steps of the replication experiment of a sheet bronze strainer-cup, from Peschiera del Garda (VE); D: final outcome of the trial. Experiments by M. & M. Binggeli.

ful balancing of tin to avoid making the sheet too brittle during the various hammering stages. Experiments by the Binggeli has regarded the reproduction of a bronze strainer-cup from the lake-side settlement of Peschiera del Garda (MÜLLER-KARPE 1980, taf. 273.42), an object probably used for filtering out impurities in alcoholic beverages (fig. 9. D). Despite its minimal shape, producing this kind of objects is possible only by well-trained people, capable of fully mastering the whole productive process; in addition, it demands the craftsman's engagement in a particularly long work, suggesting a link to full-time specialists. The forging procedure (some steps in fig. 9 A–C) has been effectuated two times, respectively by means of stone tools (hammer and anvil) and bronze tools (the same), resulting in slight differences between the final outcomes, but with the usual greater efficiency of the metal ones.

Conclusive remarks and future perspectives

At the moment we are drawing some provisional conclusions regarding the project's methodology, which deserve further reflections. A first significant result is that a continuous feedback between people with different experience and training history, or more simply with different 'skills', can be highly beneficial for the success of a real interdisciplinary undertaking like the one we have had the ambition to carry out. In spite of obvious differences in perspective and background between respectively experimental and science-oriented archaeologists, experts of protohistoric cultures and professional craftsmen, we have experienced inspiring meetings in the shared field of bronze technology and tools. A thought-provoking, and sometimes also challenging, confrontation has been established between the expert craftsmen and the archaeological team, which has contributed to the adjustment of the questions, but especially to a calibration of methods in experimental metallurgy.

A mechanism that has made advance the entire process has been to alternate bibliographical research and *de visu* observations on the archaeological record (precisely a comparative survey of Terramare and European Bronze Age metal-work tools) with periodic experiments of replication. A comparison between the two engagements, and the reciprocal reaction, have allowed to re-orient decisively questions on what shapes and materials Bronze Age smiths used to accomplish specific tasks and on how they could have handled them. In parallel, comparing working times, skills and know-how of different manufacturers (such as professional or expert craftsmen vs non-professional experimental makers) has been a valuable, though not conclusive, verification of the presumed existence of an articulation in different levels of Bronze Age smiths.

Thus, it is reasonable to say that the whole evidence for metallurgical activities in Terramare villages does speak for a production by resident smiths of medium specialized level, engaged in fulfilling the wide range of needs of whole thriving communities. The research is revealing that the technological know-how possessed by the smiths has a strong core going back to the Eneolithic and Early

Bronze Age. This is demonstrated by the broad range of traditional stone tools, but in the Recent Bronze Age the situation was rapidly changing towards a greater complexity and articulation. The production of solid-hilted daggers in the Early Bronze Age and of the long slashing swords and, especially, of laminated vessels and armour in the Recent Bronze Age has an explicitly specialized characterization, being mainly linked to time-consuming and intensive techniques that could not have been available to common workers, even though their impact from the quantitative point of view might have been limited. It is from ca 1300 B. C. onwards that we can observe a real technological transformation, visible for example in the field of the smith's toolkit that started to include metal instruments on a more regular basis, such as special chisels, punches, hammers and anvils. In the future, we wish to pursue various lines of inquiry opened by the project: specifically, issues linked to casting techniques (permanent moulds vs sand casting) and to the multiple dimensions of the smith's toolkit (stone vs bronze tools and so on). Another important goal will be to expand the communicative horizon of performances/experiments, to include a more articulate and challenging view of the post-casting process that takes into account the outcome of our investigations.

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