The Metallurgical District of Via Moneta in Milan-*Mediolanum:* The Earliest Phases

Costanza Cucini

Keywords

Iron, copper metallurgy, oppidum, Gaulish-Roman

Abstract

This paper deals with the metallurgical activities in the Celtic metalworkers' district of *Mediolanum*. Its development begun in the 4th century BC, reached its larger extension in 2nd-1st century BC and lasted until the end of the 1st century AD. For at least four centuries, there were continuous metallurgical activities in this area. The district was in the center of the *oppidum* near the area where the Roman *forum* will be built at a later stage and near the future *decumanus maximus*. Because of this in the Roman imperial period the metallurgical workshops had to move to suburban areas. The remains of 23 metallurgical workshop are both previous and contemporary to the Romanization. They were built with perishable materials and according to the local building technique. In these workshops, raw iron and copper alloys were transformed into finished objects and accessories for furniture. These workshops can be compared with those discovered in the *oppida* and in the villages of Transalpine Europe.

Introduction. From the Celtic *oppidum* to the Roman *municipium:* a short history of *Mediolanum*

The archaeological excavations in Via Moneta were carried out in the years 1986-1991 by the National Archaeological Service under the direction of Dr. Anna Ceresa Mori. The name of this street, meaning "the Coin's street", originates from the fact that the Roman imperial mint was here. This site is located in the city center, close to the *forum* of the later Roman town (Figure 1). Other excavations in some areas of the suburbia, such as Corso di Porta Romana, have uncovered metalworking tradesmen's quarters. They show that *Mediolanum* was an important production center for iron and copper alloys since the 4th century BC until at least the 2nd century AD.

This paper deals with the early phases of the metallurgic activities from theirs beginning until the end of the 1st century BC only.

In the 5th century BC Celtic groups belonging to the Golasecca culture founded Milano-*Mediolanum*, the main *oppidum* of the Celtic tribe of the *Insubres* (Barzanò, 2015; Casini and Tizzoni, 2015).

Because of their close relationship with the Ligurian tribes, *Mediolanum* had joined the trade network, which from Genoa reached far off places such as Southern Iberia and Southern Etruria (Casini and Tizzoni, 2015; Casini and Tizzoni, 2015a).

After the defeat of the *Insubres* against the Romans in the year 222 BC and after the *Boii* left Italy, new cultural influences reached the land of the *Insubres* from peninsular Italy. A deep cultural change called Romanization begins at this time; it will have taken place around the year 25 BC, at the time when the Celtic burial tradition is abandoned forever (Barzanò, 2015; Casini and Tizzoni, 2015).

Among the key factors responsible for the diffusion of Roman customs and culture, it is possible to remember the following: the foundation of the colonies of Cremona and Piacenza (218 BC) and Modena (183 BC), close to the Cisalpine territory, as well as the opening of *Via Postumia* (148 BC) joining Genoa to Aquileia and running along southern border. In addition, the frequent enrolment of Celtic mercenaries in the Roman army and the trade increase are among the key factors responsible for the diffusion of Roman customs and culture.

Between the 2nd and the 1st century BC the process of Romanization increased its pace. After the new defeat of the *Insubres* against the Romans in 194 BC, there was an increase of trade with the Romans and with their new colonies, moreover new *foedera* were made (Barzanò,

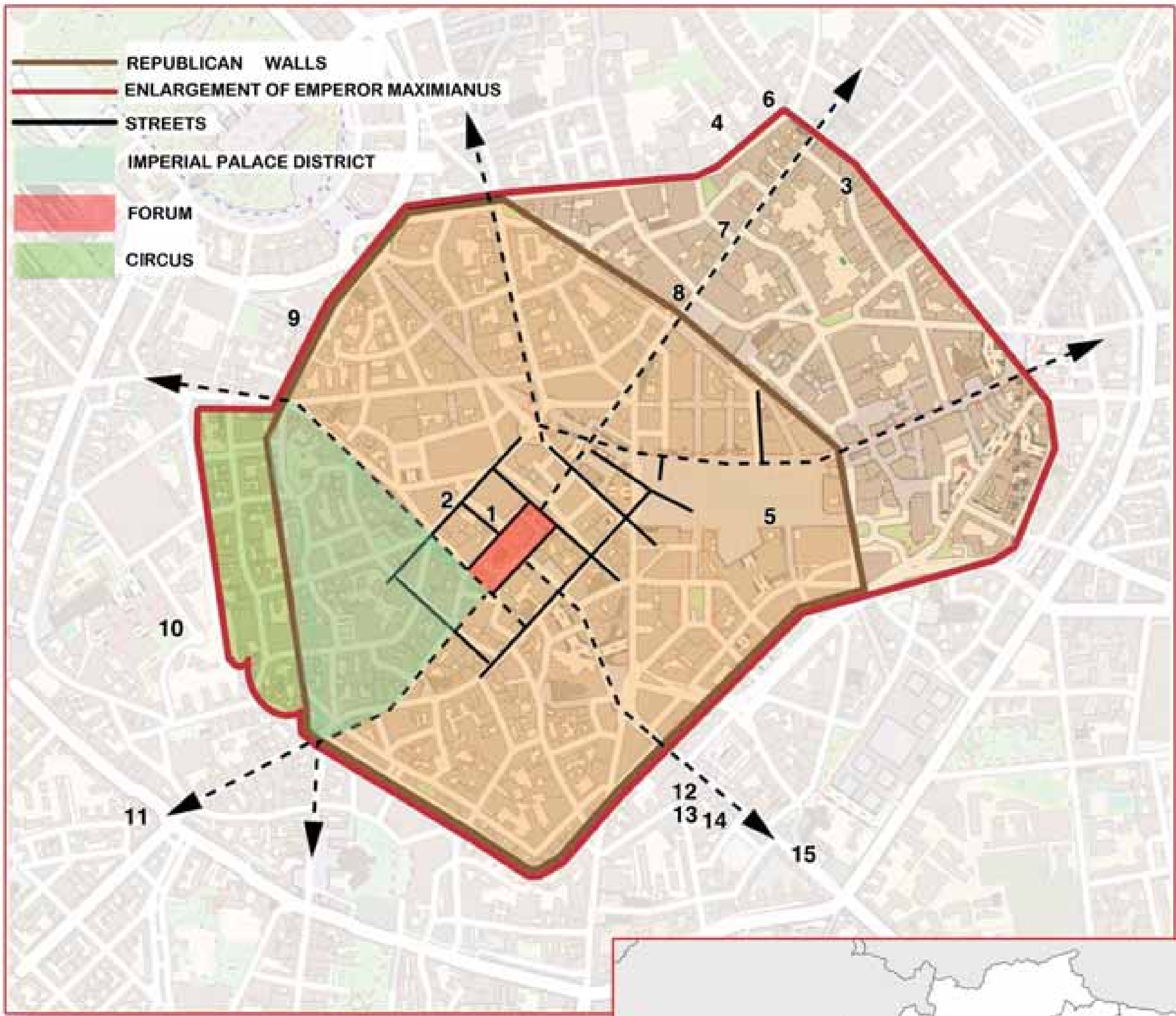


Figure 1. Map of Roman Milan with the sites quoted in the text. 1) Via Moneta. 2) Via Bocchetto. 3) Via Bigli. 4) Via Fratelli Gabba. 5) Via Arcivescovado. 6) Via Croce Rossa. 7) Via Romagnosi. 8) Piazza della Scala. 9) Via Puccini. 10) Università Cattolica. 11) Via S. Vincenzo. 12) Via Rugabella. 13) Piazza Erculea. 14) Corso di Porta Romana. 15) Piazza S. Nazaro.

2015; Casini and Tizzoni, 2015). The winners respected the independence of the Celtic territory and helped in the development of a pro-Roman positioned ruling class, which had an important role in the adoption and diffusion of an Italic life-style.

The Roman influence over the *Insubres* is increasingly stronger since the second half of the 2nd century BC. It is possible to observe it in the burial customs, in the grave goods and in the town planning. Public and private monumental buildings enriched *Mediolanum*. A town wall was built in the 1st century BC.

A recently discovered funerary stele is of great importance for our understanding of Romanization. This stele was reused and found in a 14th century building in Via Arcivescovado in the town center (Fedeli and Sartori, 2015; Casini and Tizzoni, 2015, p.147). It is made of serizzo paragneiss, it measures 215 x 60 x 30 cm and weighs about 100 kg. This stele must have been part of a memorial dedicated to a local family. It is not only important because it is the imitation of a Roman funerary stele made by a local artisan who must have seen Roman models, but also for its two inscriptions, both making reference to the same Celtic family group. The earlier was made before the year 100 BC while the later one can be dated at least to the 1st century AD. This means that the same indigenous family was rich and "Romanized" enough to have a boulder cut and a large slab from it taken as far as *Mediolanum* in order to have it carved and inscribed according to the Roman *mores*. Moreover, it shows the continuity of the same ruling families during the critical process of Romanization.

The complex relationship between the Roman Republic and these independent neighbouring territories and the interest of the Romans to trade with them. These territories outside the Roman borders were the destination of many Latin merchants, whose travels anticipated the military conquests by far. The merchants who operated in areas under Roman cultural influence could trade much more easily compared to their competitors. For example, those trading with Southern Iberia (Posidonius in Diodorus V, 36, 3) or with Gallia Narbonensis (Cicero, Pro Fonteio) (Casini and Tizzoni, 2015, p.137).

The archaeological finds show that in Cisalpine Gaul too there were Latin negotiators and entrepreneurs since the end of the 2nd century BC. They were attracted by the possibility of exploiting a land rich in agricultural and animal husbandry products and located near the Alps, an important source of raw materials.

The Cisalpine Gauls received the Latin citizenship in 89 BC and their land became part of the Cisalpine Province. Julius Caesar used *Mediolanum* as his headquarters for his transalpine military expeditions (58-50 BC) because here he had the economic and logistic support he needed. Plutarch (17, 5) informs us that in *Mediolanum* there was a rich pro-Roman indigenous ruling class and premises appropriate enough to host Julius Caesar and his retinue.

The Roman citizenship was granted to the *Insubres* in the year 49 BC and *Mediolanum* became *Municipium civium romanorum*. Then Cisalpine Gaul ceased to be a province and became part of the Roman territory. The Romans did not suppress the ruling class of the *Insubres* but they absorbed it in the republican institutions and hierarchy.

The archaeological context

The only iron reduction site belonging to this period so far discovered in the Lombard Alps is the Celtic-Roman mining and metallurgical site of Piani d'Erna (Lecco) (Tizzoni, Cucini and Ruffa, 2006). At this site (2nd-1st century BC-second half of the 1st century AD), contemporary to the metallurgical district of via Moneta, it is possible to observe the transition from Celtic to the Roman culture in Cisalpine Gaul. Here we can observe the transition from the large domed furnaces of Celtic tradition to smaller and more developed furnaces. Possibly this was due to the action of a Roman entrepreneur. This happened around the year 40 BC, when a Latin/Roman or a Romanized Celtic entrepreneur managed to acquire the ownership or lease of this site and introduced new smelting methods. At Piani d'Erna the remains of a forge were discovered too. Here the blooms were compacted and transformed into blocks of ferrite, ready for trading and usage.

At Rodano, in the Po plain close to Milan, the National Archaeological Service has dug a 2nd- 1st century BC small settlement with a forge. This atelier had a hearth similar to that of Piani d'Erna. Possibly semi-finished iron products from the Alpine area were worked here. This site is yet unpublished (study in progress by this Author).

Little is known in Lombardy about late LT (La Tène) settlements and their metallurgy. To the north of the Alps settlements of this period are known in Switzerland, for example at Courgevaux (Freiburg) (Serneels and Perret, 2007).

Further information's are only available again about the early imperial period.

The metallurgical district of Via Moneta

The earliest artisans' district of *Mediolanum* (Via Moneta) developed during the transitional period between the local "proto-urbanization" and the city planning of Romanization (Cucini, 2015). A group of metal working artisans formed an *intra muros* district at the settlement's center. It was at the western edge of the area where the Roman *forum* will be built and near the future *decumanus maximus*.

The area of the artisans' district had a surface of about 500 square meters; here iron and copper alloys were worked. The larger amount of the finds (above 90%) is from iron working. Since iron leaves more traces than copper working, we do not know if this disparity is the result of a real difference in metal production.

These ateliers witness the metallurgical development over a long period of time beginning during Golasecca III A3 –LT Ba (beginning of the 4th century BC) and lasting until the end of the 1st century AD. Its chronology is as follows:

1) 4th-3rd century BC (Golasecca III A3-LT C1);
2) Middle of the 3rd century BC-about 25 BC (LT C2-LT D2);

3) Romano-Gaulish period (Augustean Age);
4) From the age of Augustus until the end of the 1st century AD.

The study of these last two phases is still underway.

Since its earliest period (4th century BC) there was a ditch as border for the district within the Celtic settlement. In the following period this ditch was converted into a *via glareata* which had the same purpose. This shows that the inner space of the *oppidum* was structured and organized. It is possible that already in the 3rd century BC *Mediolanum* had the embryo of an urban planning with ditches and waterways whose layout was in some instances artificial. These waterways were of the highest importance for the trade activities and for the *oppidum* defence since *Mediolanum* had no natural protection.

The earliest metallurgical activities (middle 4th - middle 3rd century BC)

The only preserved stratigraphy is in the southeast part of Via Moneta. Rubbish pits with metallurgical debris (slags, burned clay, charcoal and ashes) mixed with heterogeneous household waste. The floor of an atelier where both iron and copper alloys were worked and other rubbish pits belong to the 3rd century.

In Via Moneta remains of the first phase of the Celtic *oppidum* were discovered (middle 4th-middle 3rd century BC, Golasecca III A3-LT C1). Other layers of this period were found in the Royal Palace courtyard while other finds belonging to this period have been found in the city center. They show that the *oppidum* had an area of about 17 hectares.

A few remains of buildings made with perishable materials were discovered along the ditch of Via Moneta (Ceresa Moria, 2015). They show two different building techniques: 1) Wood only. The walls were made with wooden planks placed on horizontal beams fixed into the ground and vertical struts inserted into the beams; 2) Timber frame (Vitruvius' *opus craticium*): a wooden frame inserted into horizontal beams and a thick layer of wattle and daub between.

The remains of a large rectangular building with internal partitions have been found. It can be compared with similar buildings in Northern Italy and in Gaul. There are no tiles; these buildings were sheltered with straw or wood. During the earliest phase (4th-3rd century BC) of the *oppidum* the manufacturing activities in Via Moneta are witnessed by dumping pits containing a mixture of heterogeneous domestic garbage and metallurgic waste (slags, burned clay, ashes, charcoal). They show that one or more than one forge was active, while a waste piece of a copper alloy object shows that possibly also this metal was worked since the beginning of the settlement. During the 3rd century BC, a forge's soil and other pits with metallurgical copper and iron scrap were added. Possibly the ateliers were also built with perishable materials. Until this period, we cannot name the area a real artisan quarter, but only an area where there was some metallurgical activity. During the 4th century there was another forge in the courtyard of the Royal Palace (unpublished material) at about 500 m as the crow flies from Via Moneta. Only two pits with slag were found here, which shows that not all metallurgical workshops were concentrated in Via Moneta.

The metallurgical ateliers from the 3rd century BC until about 25 BC

Romanization transformed the Celtic *oppidum* into a town, and thanks to a strong building activity it reached an area of 80 hectares. In via Moneta there was a deep transformation: all the metallurgical activities of the *oppidum* were now located here and it became an artisans' district. The main rearrangement phases can be dated to the middle of the 1st century BC. During the rebuilding activities of this period most of the earlier archaeological layers were unfortunately destroyed. During this period, the metallurgic ateliers of Via Moneta (Figure 2) were subjected to significant changes. They were now close to the settlement's center where new public buildings were under construction. An example is the large religious building in Via Bocchetto (end of the 2nd-half of the 1st century BC), not far from the place where the *forum* will be built (Ceresa Mori, 2015a, pp.62-63; Sacchi, 2012, p.43-53). It is difficult to determine if this construction was paid with the money of the Latin merchants or with that of the local ruling class, possibly related to the metallurgical ateliers. Another public building dated to the Republican-Augustean period left its traces as drums of Doric columns discovered in the Arcivescovado Palace (Sacchi, 2012, pp.54-55; Ceresa Mori, 2015, p.63). In addition to the above-mentioned stele from the 14th century building, there are two architectonic fragments (about the half of the 1st century BC) in Via Bigli and the remains of at least three memorials belonging to the second half of the 1st century BC in Via Fratelli Gabba. All these remains show that there were wealthy citizens in the *oppidum* (Casini and Tizzoni, 2015, p.147; Ceresa Mori, 2015a, pp.62-63).

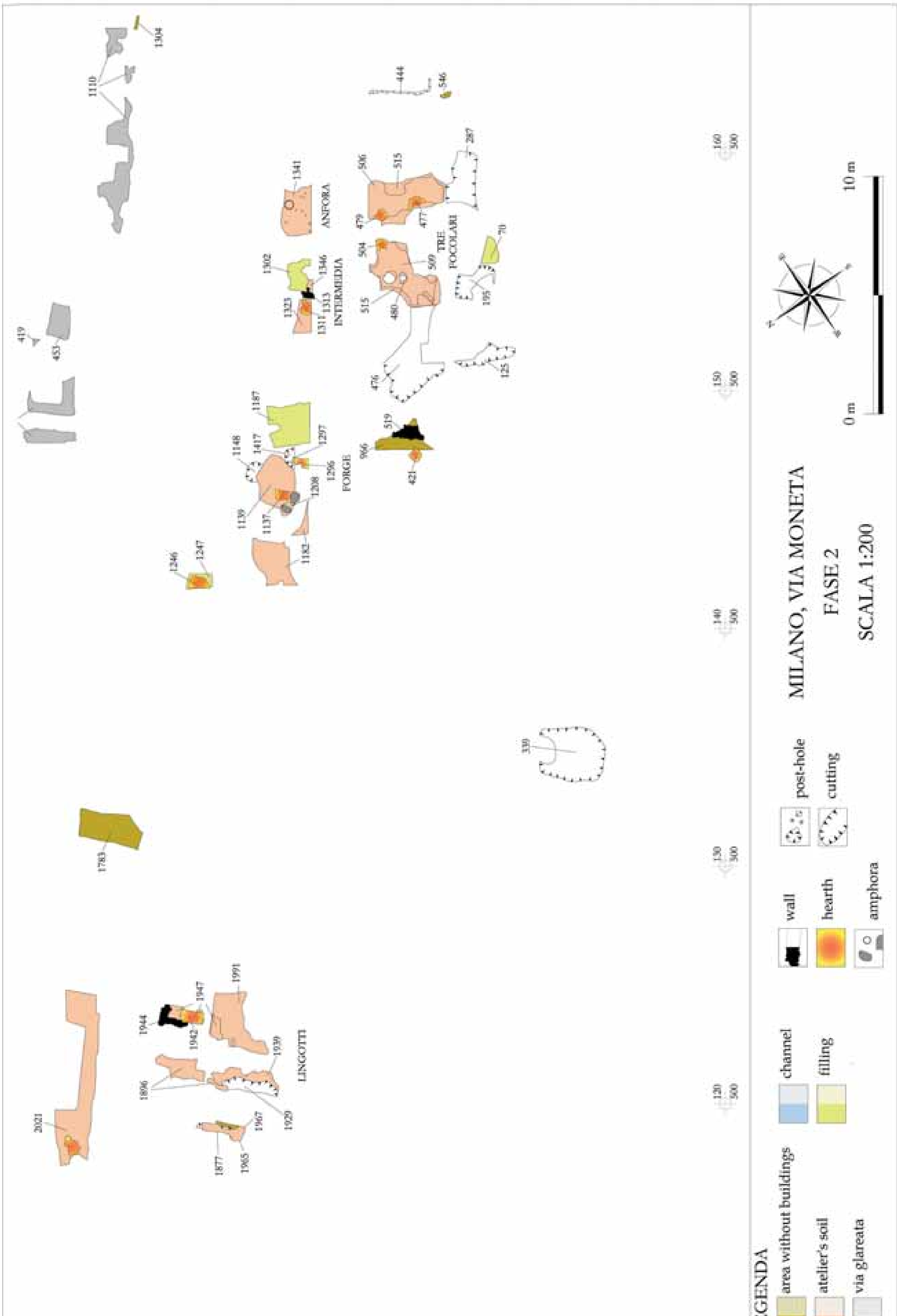


Figure 2. Plan of the metallugical district of Via Moneta during its strongest development (3rd-1st Century BC), from Cucini (2015, Fig. 1).

The metallurgical district of Via Moneta was preserved over an area 50 m long, with an average width of 10 m. It is difficult to reconstruct its plan correctly because later buildings with deep basements were built in the same area. We can recognize a few variations in the building technique of these ateliers between the 4th and the 1st century BC. They had wattle and daub walls and sometimes tiled roofs. Walls of stone appear only in the 1st century BC, when not only the district but the whole *oppidum* were reorganized and re-planned. The increase in metallurgical activities since the 3rd century BC could be connected to weapons production, because it was a period of continuous clashes and battles against the Romans. Close to the ateliers, there were wooden buildings of unknown use; they could have been the artisans' dwellings.

Iron working ateliers

In the district of Via Moneta various metallurgic ateliers were active at the same time. By ateliers we mean "un espace organisé que diverses installations structurent" (Serneels, Merluzzo and Leroy, 2004, p.97).

There were twenty-three ateliers active in the 3rd-1st centuries BC, often they were rebuilt one above the other and their majority belongs to the 1st century. Their walls were made of perishable materials so they are very poorly preserved. Their floors were made of pressed soil, pebbles, and gravel and covered by layers of charcoal, ashes, waste, burned clay and sand. This kind of architecture is Celtic and it can be compared to that of the transalpine *oppida* and open settlements. Since these waste layers do not show any weathering, these buildings were roofed or had awnings.

The model suggested by Ducreux (1999, pp.189-192) for the copper metallurgy ateliers of Autun-*Augustodunum* has been used in the categorization of the forges' hearths: building material, shape and position on the ateliers' floor (on the surface, below it), degree of reddening of the hearths' walls and bottoms. All these structures and features were dug into the soil or were at the ground's level, as it was common in contemporary Celtic and Roman settlements. Since clay is rather rare in the area, they are not always lined with it. They can be classified as follows:

1. Bowl-shaped hearths dug into the ground (Figure 3: 1, 2, 3). They are shallow (10-24 cm), small, circular (diameter 60 cm) or ovoid (50 x 80, 70 x 100 cm) pits. They may be, but not always, carefully made and are strongly reddened inside. It seems that sometimes they had a partial covering, which very so often found collapsed inside. These types of hearths can be found at many contemporary sites. For example: at La Porte du Rebout at *Bibracte* (Pernot, 1998a, p.57), at the *oppidum* of Vernon-Le Camp de Mortagne (Bauvais and Fluzin, 2014, pp.135, 141, Fig. 13) and in Provence at *Olbia* in a period dated between 40- and 30 BC (Pagès, 2008, p.89). Also, during the early centuries of the Roman Empire. For example: at Luneil-Viel near *Ambrussum* in Languedoc-Roussillon (Pagès, 2008, pp.95-97), at the Romano-Gaulish village of Blessey (Côte-d'Or) (Mangin, et al., 2000b, pp.236-238), in the metallurgical district of Lycée Militaire of Autun-*Augustodunum* (Serneels and Chardron-Picault, 1999, pp.206-209), at the Romano-Gaulish village of Bliesbruck in Lorene (Forrières, Petit and Schaub, 1987, p.13).

Similar bowl-shaped hearths were found in a sub-urban settlement of Milano-*Mediolanum* dated to the last decades of the 1st century BC. Unfortunately, almost all the metallurgical waste at this site was redeposited and its interpretation is unreliable both in its content and conclusions (Grassi, 2016, pp.71-85). Much of the same can be said about the 1st century AD Seminario Vescovile site in Verona. Grassi's (2016, p.193) statement that there were occasional ore reduction activities in both Milan and Verona is however without any foundation.

2. Deep flat-bottomed hearths with sloping walls (Figures 3: 4, 5, 6). Possibly, they were used during the assembly of bronze and iron objects, which needed not too high temperatures. They were sub-circular pits just a little deeper than the previous type (average depth 30 cm), they had sloped walls and a flat bottom. They are just slightly reddened; the fragments of their walls are found inside.

3. Hearths formed by a simple reddened area at ground level (Figure 4, A). They are flat areas of sandy clay almost circular in shape (diameter 60-70 cm). Sometimes their edges are blurred. They show to have been exposed to a strong heat, because they are hardened and strongly reddened. Nevertheless, it is difficult to understand their functions because there are no structures connected to them. We must bear in mind that these reddened areas could be all what remains of the forges' hearths after they were demolished by later buildings construction. In addition to the hearths above mentioned, reddened sandy clay areas were found, which were also observed at many other sites.

In *Bibracte*'s iron forge, they were interpreted as hearths for reheating large pieces of metal sheet (Pernot, 1998a, p.57). In the large *oppidum* of *Alesia* (Haut-Auxois, Côte-d'Or), where dozens of iron and bronze smiths work-shops have been excavated, there are also flat and reddened hearths in Ensemble 27, at the edges of the fu-

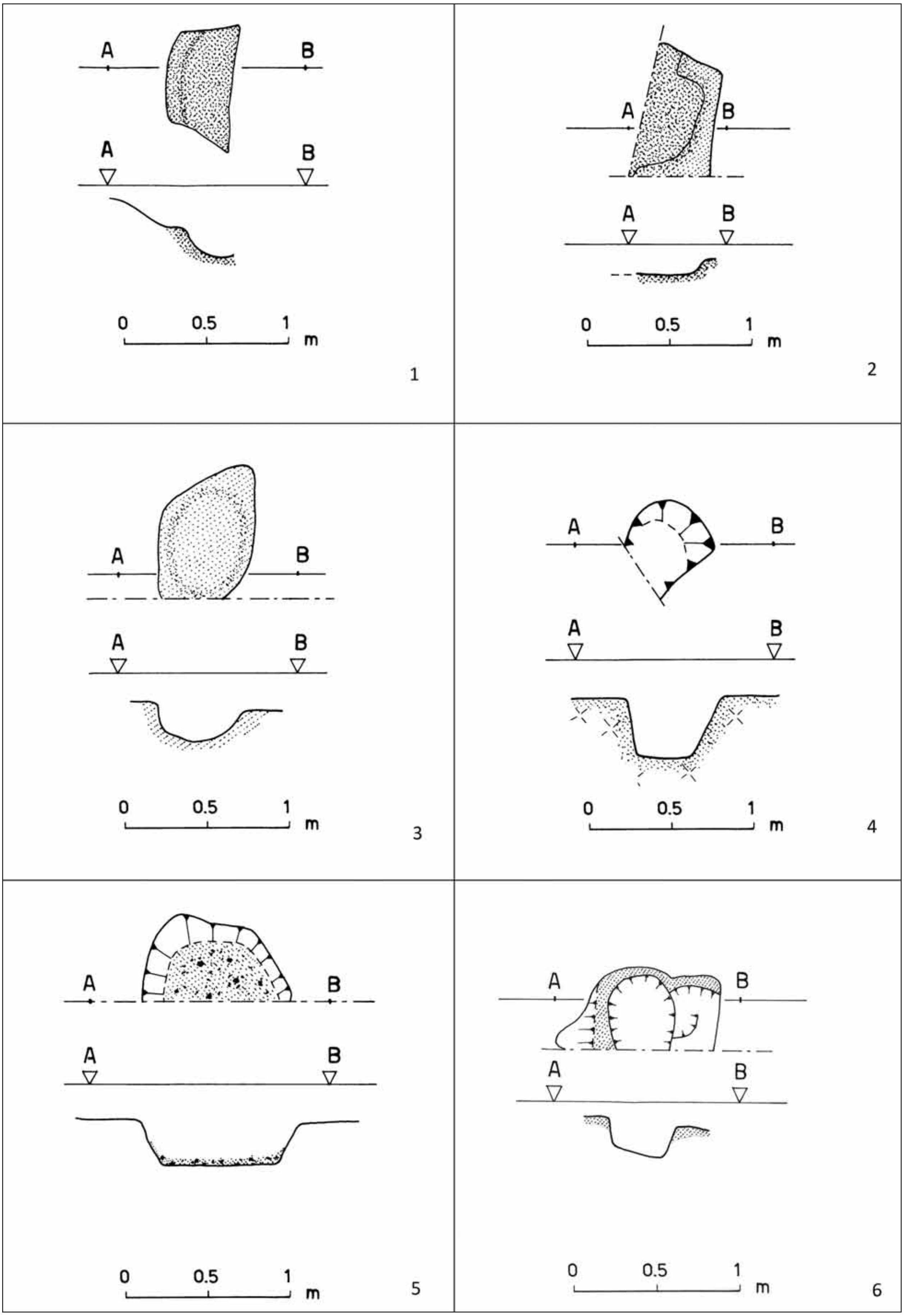


Figure 3. Iron working hearths. Categorization. 1) Bowl shaped hearth dug into the soil US 1137. 2) Bowl shaped hearth dug into the soil US 1297. 3) Bowl shaped hearth dug into the soil US 1329. 4) Deep flat-bottomed hearth with sloping walls US 420. 5) Deep flat-bottomed hearth with sloping walls US 1245. 6) Deep flat-bottomed hearth with sloping walls US 1311, from Cucini (2015, Fig. 16).

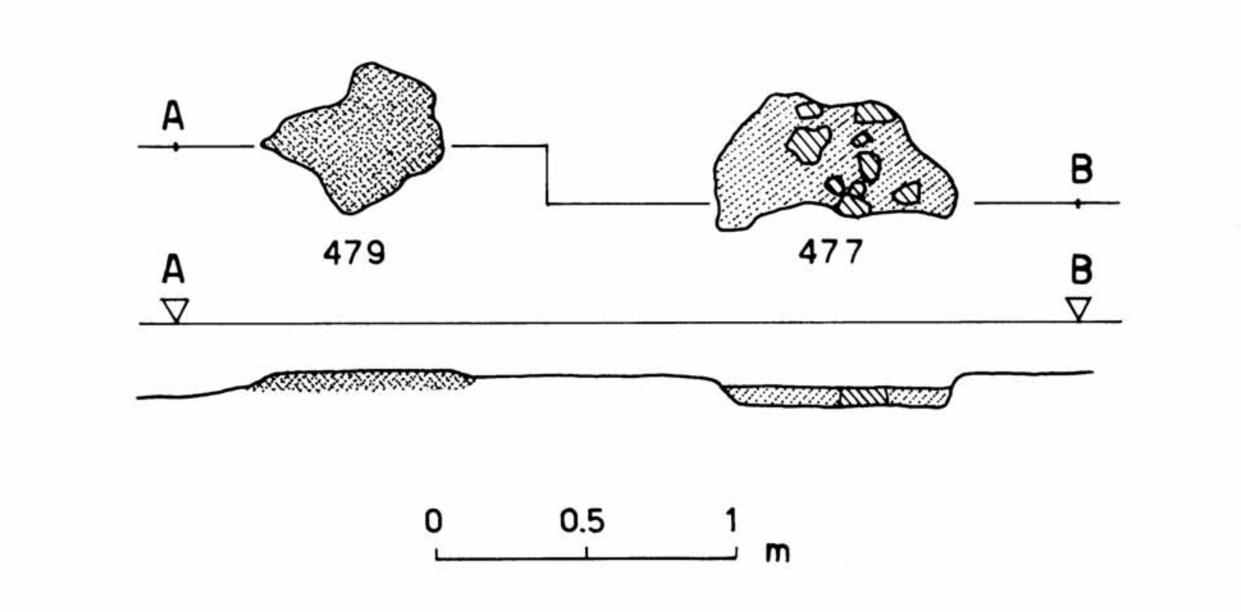


Figure 4. Iron working hearths. Categorization. 1) Hearth formed by simple reddened area at the soil's level US 479. 2) Bricks formed hearth US 477, from Cucini (2015, Fig. 17).

ture Roman *forum*, dated the period 40-30 BC / 10 AD (Mangin, et al., 2000a, pp.92-96). Similar discoveries are at Lunel-Viel in the first phase of the forge activity (Pagès, 2008, p.96) and at Autun-*Augustodunum* in the Lycée Militaire district (Serneels and Chardron-Picault, 1999, pp.208-210, Fig. 170). In Italy at the metallurgical site of Piani d'Erna (Lecco) an area of reddened clay (diameter 79 cm) was discovered on the floor of the forge-hut, a simple awning made of perishable materials dated to the half of the 1st century AD (Tizzoni, Cucini and Ruffa, 2006, pp.45, 48, 83, Fig. 31, 35).

Areas of burned and strongly reddened soil were found in Piazza del Duomo (Perring, 1991, p.105-162) at 300 m as the crow flies from Via Moneta. They were dated to the end of the 2nd century -50/30 BC, and they were no further investigated.

4. Flat hearths formed by bricks (Figure 4, B). Only two poorly preserved structures were discovered in the district of Via Moneta. They were inside a shallow pit. One was formed by bricks' fragments lain on a burned and flattened surface of loamy soil with a lot of charcoal and ashes. Flat lain fragments of *tegulae* and reddened clay formed the other. Similar finds are from: Biberist (CH) (Schucany, 1994), Bliesbruck (Forrières, Petit and Schaub, 1987, pp.11, 13), Autun-*Augustodunum* in the Lycée Militaire district (Serneels and Chardron-Picault, 1999, p.210, Fig. 168:3 and 170). There in room 2-3, the central hearth was formed by two *tegulae* lain flat with *imbrices* at their sides.

5. Quadrangular pit hearths. Only one poorly preserved example. Apparently, it was a rectangular pit. The preserved part measured 60 x 53 cm and 30 cm in depth, but in origin, it must have been much larger. It had sloping walls and a slightly concave bottom. It was dug into the atelier's floor and filled by burned clay, which was the rubble from its walls and possibly its covering. Possibly the burned clay discovered inside belonged to some sort of fire protection for the bellows. Because of its shape, we suggest that this hearth was used for long iron objects (swords?). Similar hearths are at *Alesia*, Ensemble 17b at the edges of the future Roman *forum* (hearth F1744) (Mangin, et al., 2000a, pp.238-240), at Châbles-Les Saux (Fribourg, CH) (Anderson, et al, 2003, pp.85-88; Anderson and Serneels, 2004, pp.98-99), at Autun-*Augustodunum* at the Lycée Militaire site (Serneels and Chardron-Picault, 1999, p.210). In Milan in Via Puccini two rectangular hearths with edges formed by bricks were one close to the other, but in two different rooms, possibly in order to avoid dispersion of heat (Tizzoni, 1997; Tizzoni, 2014, p.262).

The hearths annexes: bellows, *amphorae* and charcoal deposits

The *amphorae* bottoms and bellies were structural annexes of the forges. They were used as containers for water and additions used during heat and mechanical treatments of iron and of copper alloys. Two large and elongated Dressel 1 *amphorae* cut across their length were lain close to a forge's hearth. Two Lamboglia 2 *amphorae* stuck vertically in the atelier's floor. They were cut

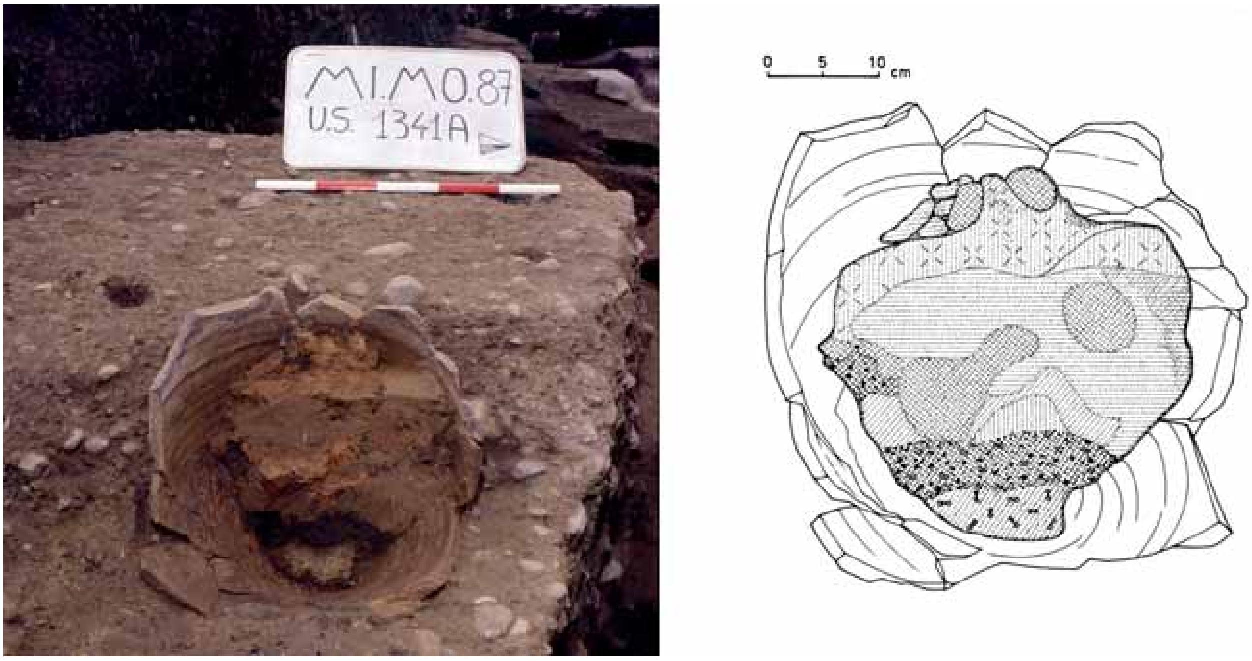


Figure 5. *Amphora's* bottom US 1341 A, photo and drawing during excavation, from Cucini (2015, Fig. 19).

just below their necks; also, their feet were taken away. One *amphora* was filled by sediments: burned, hardened and bright red clay mixed with charcoal and ashes above some thick iron concretions (Figure 5). Further *amphora* fragments with iron incrustations were found in the metallurgical waste dumps. They must have been used in the ateliers and replaced when broken.

The achaeometallurgical study of the slags has shown (Tizzoni, 2014, pp.230, 254-262) that ashes were added as fluxes during soldering and other operations. Water was used in order to dampen the hearth's edges, to cool down the larger objects and the forgers' tools and possibly for tempering, even if there is no evidence for this treatment. With regard to these many work steps, reuse of *amphorae* in forges was quite common, as they still provided valuable services even when damaged. A few examples are given here: at Levroux, Vinçon sector (early 2nd-early 1st century BC) the belly of an *amphora* used for tempering (Berranger and Fluzin, 2014, p.123), at *Bibracte* the bottom half of an *amphora* stuck into the soil of the atelier in front of the northern rampart (80-40 BC) (Pernot, 1998a, p.57) and in the atelier found at the foot of the southern rampart of the Porte du Rebout (Paris and Berranger, 2014, p.302), in Provence at *Olbia* a forge (40/30 BC-20 AD) the bottom of an *amphora* filled with sand (Pagès, 2008, p.89), at Bliesbruck, at Lunel-Viel, at *Alesia* and at Hettange-Grande (see Cucini, 2015, p.415). The site where reused *amphorae* are in almost every atelier is the Lycée Militaire district of Autun-*Augustodunum* (Ducreux, 1999, p.193; Serneels and Chardron-Picault, 1999, pp.208-209, Fig. 170).

In Via Moneta fragments of tuyeres are common. They protected the bellows from the heat of the hearth and had one central hole only.

Unfortunately, no anvils or forging tools were found since they were carried somewhere else after these ateliers were abandoned and transferred, at the end of the 1st century AD, to other districts of the town. This happened because this area close to the *forum* had become residential and monumental, so the artisans had to move towards the suburbia.

The dumping pits and the problem of the metallurgical waste management

Slags and metallurgical waste were removed and periodically dumped into apposite pits, or in communal rubbish pits, as in other Romano-Gaulish settlements (Kasprzyck and Labaune, 2003; Monteil, et al., 2003). At first, in the 4th century BC, the metallurgical waste represents just a smaller percentage of the overall waste of the district; this means that metallurgy was not yet the main activity there. The first pits used were the ones where general household rubbish was dumped. In the first half of the 1st century BC, old disused wells and sand pits were used for dumping metallurgical waste. Later the generic rubbish pits containing metallurgical waste become very numerous. Then the inhabitants dug new pits with the only purpose of dumping metallurgical waste. Iron slags, waste from copper alloys, charcoal, ashes and lumps of burned clay form their filling. Their distribution in the

Figure 6. Samples of iron waste from 3th-1st century BC forges, from Cucini (2015, Fig. 22).

settlement shows the extension of the artisans' district and where it was moved at a later stage. At first, the rubbish pits seem to be the results of the spontaneous initiative of the inhabitants. When the metallurgical activities increased during the 1st century BC, it became basic to have a clean and waste free working area. Because of the extent of the artisans' district and the large amount of metallurgical operations, the waste thus produced must have reached impressive amounts (Tizzoni, 2014). The pits contain both iron slags and copper alloys waste. This means that the copper and iron working ateliers were close, simultaneous and used the same dumping pits. The same was observed at *Alesia* (Mangin, 2000a, p.94), while at Rheinau-Altenburg (Zürich, CH) (Senn, Schreyer and Serneels, 2014, Fig. 2) there was a clear detachment between the working areas.

The iron waste

The smithy slags have been studied and analysed (Tizzoni, 2014). All of them belong to the last phase of the operation sequence in direct iron production. Semi-finished products reached Milan in order to be transformed into finished objects. The plano-convex bottom finery slags (PCB) (Serneels and Perret, 2003) are small or middle sized. There are also clay-sandy slags (scories argilo-sableuses, SAS). They have a very low metallic iron content (small or very small particles, rarely as droplets). This shows that the metal loss was minimal. The smiths cleaned their forges' hearths regularly. They used short, homogeneous and regular heating cycles. They were specialized and organized workers who had a very good knowledge of iron treatment.

The soils inside the forges can be quite thick and plenty of metal waste was found inside (Figure 6). By metal waste, we mean the metal fragments cut out of an already compacted piece of metal, or while shaping it (Anderson, et al., 2003, pp.107-130). Small iron nails with their heads covered in bronze lamina were one of the products. Among the waste, there are many fragments of iron sheet suggesting the productions of weapons (shield umbos?) and wheel rims. In order to hold firmly the iron object during its forging the smiths used to attach a triangular peduncle to it. By holding it with their thongs, they forged the object and cut the peduncle off when its forging was over.

Hammer scales have been recovered from the only carefully excavated hearth. They can be larger than 1 mm or smaller. They are formed by magnetite and wüstite. They are grey-bluish in colour or rusty. Their shape can be scaly, globular or granular, but their predominant shape is the scaly one. This shows they were produced during the last phase of the forging, hot hammering. There are also finds of metal filings.

The forges: conclusions

All the structures were at ground level: hearths, bellows, water and containers for additions. The smiths worked squatting and not standing in front of the forge. The earliest raised-bench forge in Lombardy is that from Monte Barro (Lecco), dated to the 5th-6th century AD (Cucini and Tizzoni, 2001). In general, no ingots, bars or any semi-finished metal were found. It is possible that the iron blooms were traded after receiving a first rough hammering and shaping. Two examples (33 and 38 kg in weight each) of this poorly known group of semi-finished works come from the forge-hut of Piani d'Erna (Lecco) dated to the 2nd century BC-1st AD. They are made of ferrite (Tizzoni, Cucini and Ruffa, 2006), a kind of iron which can be easily forged. A raw semi-finished product of excellent quality, having remarkable mechanical properties making it fit for the forging also of heavy objects (Fluzin, 2006; Fluzin, et al., 2012). It is not known if the iron from Piani d'Erna reached *Mediolanum*, but it cannot be ruled out that contemporary semi-finished products from other production sites in the Lombard Alps were similar in shape and weight.

The different types of the forges' hearths show different and complementary activities. The circular or ovoid bowl hearths were suitable for heating small or roundish pieces. The flat hearths were used for re-heating during certain working stages. Some hearths were used for smelting the copper alloys necessary for the production of composite objects. For the elongated and large pieces of iron, the quadrangular hearths were used because of their higher thermic inertia.

Copper-alloy objects' production

The alloys used were tin bronzes to which lead was added or simply binary Cu-Pb alloys (Cucini and Riccardi, 2015). Brass production seems to begin in the 1st century AD in the suburbium of Corso di Porta Romana. There is no evidence for it in Via Moneta phases I and II. Brass production in Cisalpine Gaul seems connected to the Roman period (Ceresa Mori and Cucini, 2012).

A small furnace belonging to a type suitable for copper alloys smelting in crucibles was found; the crucibles used for this purpose were of appropriate dimensions. Presently there are no accurate and in-depth analyses

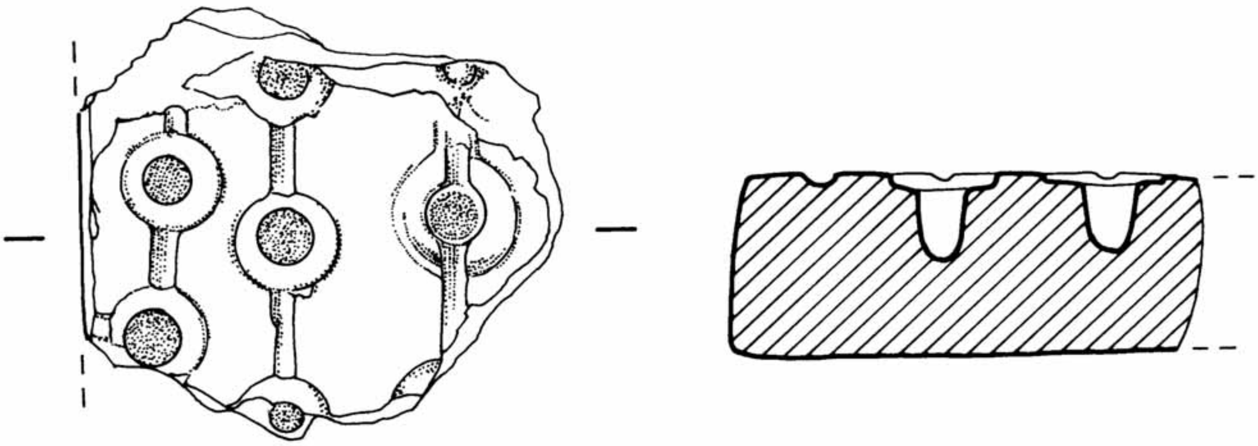


Figure 7. Cluster mould for copper-alloy upholstery nails, form Cucini (2015, Fig. 29).

of this metallurgical waste. For this reason, we cannot say whether these alloys were produced here or whether they arrived in *Mediolanum* as finished products. It is possible that scrap metal was also recycled.

There is no evidence for lost-wax mould casting, but only one clay cluster mould (Figure 7). The bronze sheets cold hammered on wooden anvils could be less than 1 mm thin. A reheating in appropriate hearths followed each stage of their hammering.

The bronze workers ateliers were similar to those of the smiths. They were made with perishable materials; they had a tile roof and a pressed soil ground with hearths dug into it.

There were ateliers for copper alloys casting and ateliers for after casting operations (Pernot, 1998b). There were circular smelting furnaces dug into the atelier's soil, low annealing furnaces at soil level, or deep furnaces used during the after-casting operations. The casting furnace US 1123A is the last in a series of small overlapped furnaces built one above the other. Its bottom is almost circular (diameter 56 cm, height 12 cm) (Figures 8 and 9). We cannot establish how many times these casting structures were built one above the other. Their shape was almost cylindrical; it was not possible to reconstruct their inner diameter. They were open at their top and made of clay-rich soil, their inside walls

Figure 8. Furnace US 1123A for copper alloys and the hearth of the forge US 1137 during excavation, from Cucini (2015, Fig. 11).

were black (Rottoli, 2015). In the soils of three ateliers there are small posts holes (diameter 4-9 cm) belonging to the frames supporting the partition walls dividing the hearths area from the other parts of the atelier.

As in the forges, *amphorae* were used also in the bronze ateliers. They were placed in or above the ground. The concretions in one of the *amphorae* were composed by iron oxides and contained a fragment of the bronze lamina used as covering of iron nails.

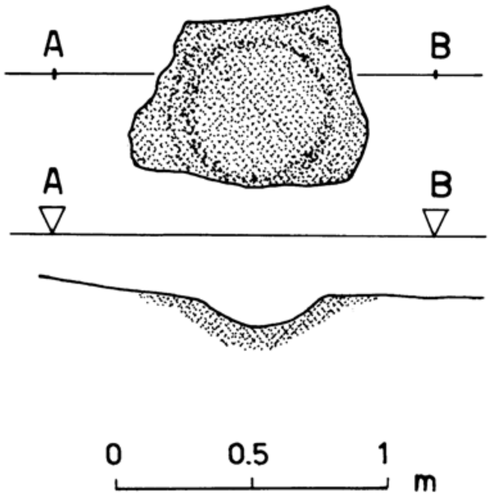
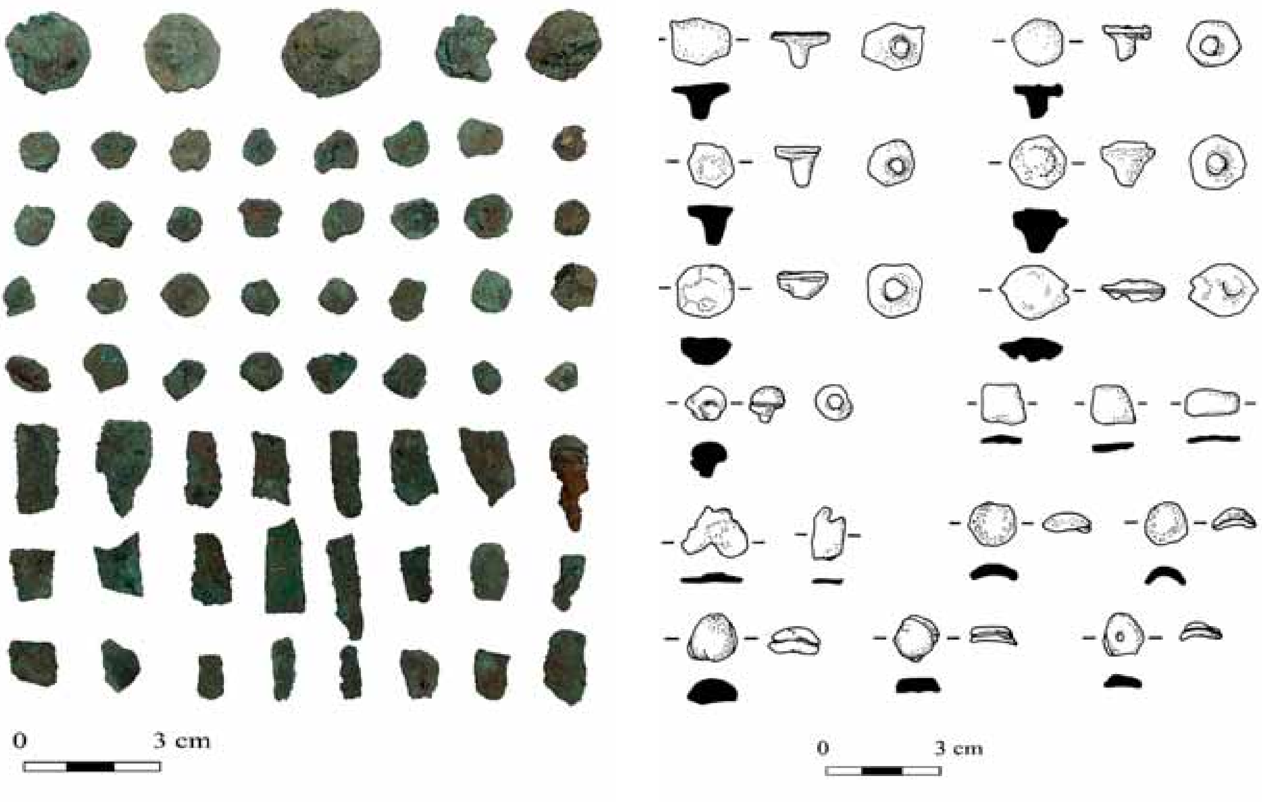


Figure 9. The copper-alloy melting furnace US 1123A, from Cucini (2015, Fig. 30).

The copper alloys' production scraps

The main products of alloyed copper from the district of via Moneta were rivets and upholstery nails of various measures, small bronze nails, larger nails and laminas used as coverings for the heads of iron nails and objects made of bronze sheet (Figure 10). These upholstery nails were used in order to secure the cloth or the leather to a wooden frame (chair, set, bed). They have a round head and a short shank (diameter 1.3-2.3 cm; shank length 0.5-0.7 cm; average weight 2.38 g). They are of a binary Cu-Pb alloy and were made by pouring molten metal into a clay cluster mould. The small bronze nails have a spherical head (diameter 1.2-1.5 cm) and a short and very thin shank (length 1.3-1.6 cm). The small and thin lead bronze laminas have a diameter of mm 0.8-1.1 and an average weight of 0.47-0.77 g. Cut out of a thin metallic sheet, they were beaten in order to make them concave. These tiny laminas were used as covers for the heads of the iron nails and had an aesthetic purpose. They have been found all over the artisans' district and are dated between the half of the 3rd century and 25 BC. They are not welded to the nail's head, but just bent over it. Similar nails are those of the wooden chest found at Pompeii in

Figure 10. Copper-alloy waste, photo and drawing, from Cucini (2015, Fig. 31 and 34).



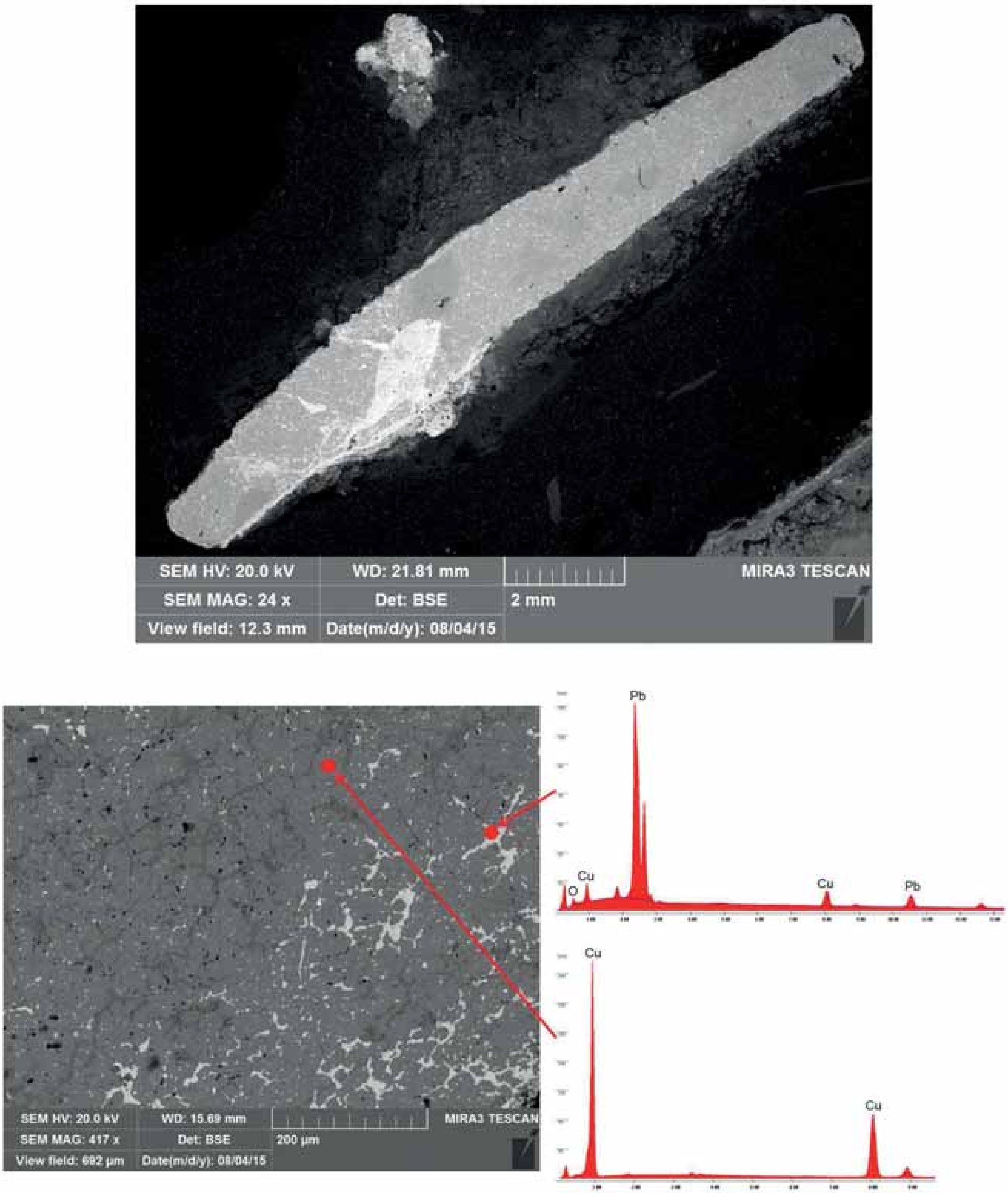


Figure 11. SEM image of the small upholstery nail from 1145 al SEM. Macro photo. Transverse section. Scanning electron image (BSE) of its texture; the ESS spectrum show the chemical composition of the alloy, from Cucini and Riccardi (2015, Fig. 3 and 4.1).

the house of Trittolemus (VII.7.5). This chest, dated to the 1st century AD and now in Naples' Archaeological Museum, belongs to a kind of furniture quite common in Roman houses. It was coated with iron sheets nailed on it with iron nails with their heads covered by tiny bronze laminas (Melillo, 2016).

The fragments of *fibulae*: production or recycling?

Fragments of *fibulae* belonging to the Misano (125-50 BC) and Nauheim (50-25 BC) types were found (Rapi, 2015). These fragments of *fibulae* may have been just metal scrap to be used for recycling. In *Mediolanum*, however, there might have been a production of *fibulae* as in other Celtic *oppida* such as *Bibracte* (Pernot, 1998a, p.54) or in Southern Bavaria near Manching (Schwab, 2014).

The products and the copper alloys composition

The ateliers produced upholstery nails, bronze nails, coatings/overlays for iron nails, custom-made products involving both the smiths and the bronze workers. This explains why they worked in the same ateliers. The products were accessories for furniture, nails to secure leather to wood, for example *sellae curulis* and beds, bronze appliques, locks, keys and hinges for pieces of furniture and doors.

Five specimens from layers clearly belonging to the Romano-Gaulish period were chosen. Each of the main groups of scrap metals has been analysed at the Laboratory of Pavia University by optical microscopy and Scanning Electron Microscopy with energy dispersive X-ray spectroscopy (SEM-EDS). These analyses were carried out by M. P. Riccardi, Associate Professor of Applied Petrography, Earth and Environmental Sciences Dept., Pavia University. The specimens were encased in epoxy resin and polished with abrasives up to 0.25 μ and then had a graphite metallization for SEM exam.

One upholstery nail with a round head and a short shank (weight 3.87 g, diameter 19 mm) was formed by a binary Cu-Pb alloy. Lead does not have a homogeneous distribution in this alloy but tends to concentrate around the edges of the copper grains. Because of this, this alloy tends to be fragile explaining the large number of faulty products (Figure 11). In general, the copper alloys were seldom tin bronzes. Most frequently, lead was used or added to tin bronzes. Possibly bits and pieces of heterogeneous copper alloys were recycled (Cucini and Riccardi, 2015).

The rusty concretion at the bottom of an *amphora* found in one of the ateliers contained charcoal, siliceous sand, splinters of oxidized iron and fragments of bricks and the fragment of a nail cover. They were stuck together by a matrix formed by iron hydroxides. A ternary Cu-Sn-Pb alloy forms this cover (Figure 12). It shows an uneven distribution of its components, there are areas richer in Pb and Sn than in Cu. At Bibracte, at the foot of the southern rampart of the Porte du Rebout, the *amphorae* used for tempering showed a similar sediment (Paris and Berranger, 2014, p.302).

A detailed macroscopic study of the wastes and of the metallic fragments from Via Moneta is still missing (about the methodology for this study see Anderson, et al., 2003). More SEM analyses of the composition of the copper alloys fragments would be necessary as well.

The artisans' district of Via Moneta: conclusions

The district of Via Moneta in Milan is an exceptional example of a Celtic and Romano-Gaulish metallurgical district in Cisalpine Gaul, where sites comparable to those of Transalpine Gaul have not been discovered to date.

This district was *intra muros* at the center of the settlement and was allocated for metal production since its foundation. There were other areas in *Mediolanum* where metals were worked in later periods, but they were smaller, suburban and rather short lived, but since we have only partial data about them, we cannot draw any firm conclusions yet. Semi-finished metal products arrived to *Mediolanum* in order to be transformed into finished objects. No evidence of ore reduction was found in the entire metallurgical district.

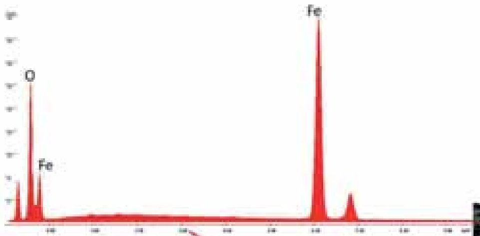
Since their beginning in the 4th century BC, these ateliers were built along a ditch, which was the border of the metallurgical district. Later on, this ditch became a *via glareata*, an important communication route. Comparable ateliers built along a ditch can be found in the *oppida* of Zavist and Stradonice in Bohemia (Danielisovà, 2014), at Bibracte, at Condé-sur-Suippe and at Villeneuve-Saint-Germain (Fichtl, 2013). At Manching the *oppidum*'s plan possibly mirrors the functions of the different districts. In the *oppidum*'s central part of Altenfeld there was the artisans' district along the East-West street (similar to a *decumanus*) formed by small huts used as workshops (Sievers, 1993; Schwab, 2014).

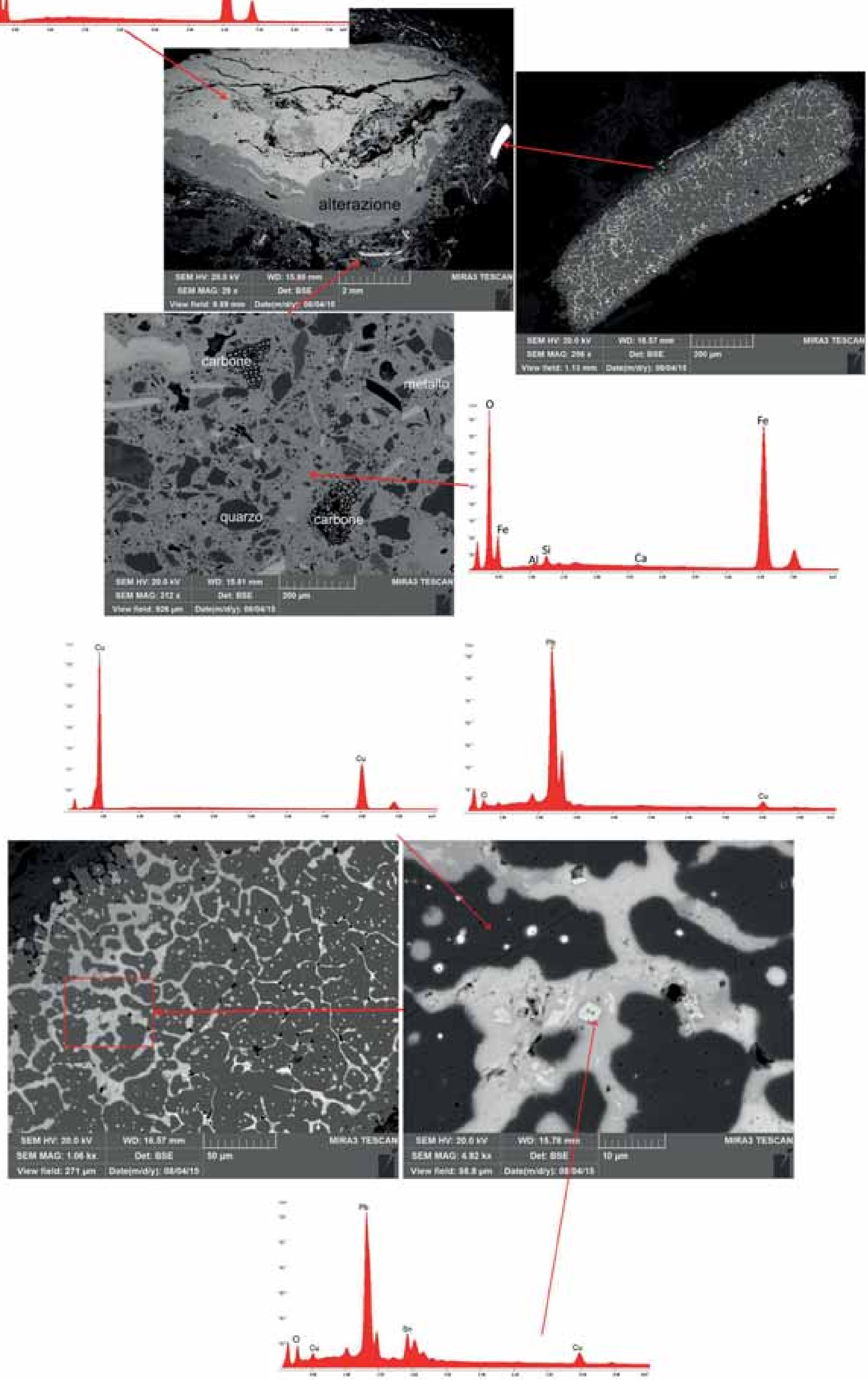
The continuity of the ateliers in via Moneta and their concentration at the same spot shows that these metallurgical operations were not occasional but permanent even if they seem to have developed mainly in the 1st century BC. Possibly this is due to the removal of most of the 2nd century layers during the Roman urbanization of the town (Ceresa Mori, 2015; Casini and Tizzoni, 2015).

The archaeometallurgical study of the forges and of the copper alloys working atelier has shown how their productions were complementary. Iron and copper were worked in nearby ateliers. Sometimes the same ateliers and their hearths were used during some operations involving both iron and copper.

Metal production was highly specialized. Various iron items and iron sheets were made, fluxes were used

Figure 12. Transverse section and details of a rusty concretion at the bottom of an *amphora* from US 1341. The metal fragment is formed by copper grains with interstitial lead and tin, from Cucini and Riccardi (2015, Fig. 5).





for soldering. Copper alloys were used for the production of nails, rivets, upholstery nails, thin bronze sheet was made in order to cover the heads of iron nails and possibly also late La Tène *fibulae* of Misano and Nauheim type or of related types were made. These metallurgists with their Celtic traditions were highly specialized and had a superior expertise. Different artisans, mastered in different tasks, worked together in order to make composite objects. This explains why their ateliers were in the same district. Anyhow, there must have been other reasons for this: the concentration of noxious fumes and waste, an associated market place and may be a "political" control of the exchanges. We do not know if this was the result of an intentional settlement planning or it was just for trading ease. During the 1st century BC, building technique and urban planning changed here as all over the settlement: the ateliers became masonry buildings orientated NE-SW. This rationalization and organization of the area determined an increase in its metallurgical output. During the metallurgical activities' peak, hearths for copper or iron were positioned one above the other on filled up dumping pits. This shows an intense and continuous activity. Possibly this metal production was well above the town's needs. *Mediolanum* was the market place for long distance trades. As it happened in other Romano-Gaulish towns these ateliers-shops assisted the local clients with their mass production. The making of these metal objects means that there was a net of specialised artisans working for the town clients and possibly also for a wider market. Large amounts of charcoal must have been used in the settlement and this implies a well-organized network of production, transport and trade of this commodity.

Iron and copper working are common in many *oppida* and in some open settlements in Transalpine Celtic Europe. For example, at *Alesia* (Mangin, et al., 2000a, pp.88, 91-93; Mangin and Fluzin, 2006), at *Bibracte* (Pernot, 1988a; Guillaumet and Labaune, 2011; Berranger, Duval and Serneels 2014), at Condé-sur Suippe and at Villeneuve-Saint-Germain (Bauvais and Fluzin, 2014, pp.135, 140) in France or at Rheinau-Altenburg (Senn, et al., 2014) in Switzerland. Varennes-sur-Seine (FR) is a settlement of artisans working various metals aimed to a common final production (Bauvais and Fluzin, 2014, pp.142-143), as it happened in Milan. The same occurred in the open settlement of Levroux-les-Arènes (FR) where both iron and bronze were worked (Berranger and Fluzin, 2014, p.12) and at Berching-Pollanten (D) were iron, bronze, wood and leather were worked (Fichtl, 2013). At the *oppidum* of Kelheim there was a bronze foundry at the middle of the 1st century BC (Schäfer, 2001).

The most interesting comparisons are from the Celtic *oppidum* of Manching where both iron and copper alloys were worked. Recent analyses of 600 finds such as Nauheim *fibulae* (Schwab, 2014) have shown that a standardized copper alloy rich in antimony was used, even if there is evidence for the recycling of copper and of a copper-silver alloy. At Manching, abandoned before 15 BC, there are no traces of brass production, as in Via Moneta.

The peak of the production in Via Moneta began at the end of the 2nd century BC and lasted until the Flavian period. Since the end of the 1st century BC, *Mediolanum* undertook a remarkable financial effort in the refurbishing of its center. The construction of the forum and of the *decumanus maximus* compelled the metallurgists of Via Moneta to move somewhere else. Milan's *forum* was built in the period of Augustus and paved within the first half of the 1st century AD. Gradually the ateliers had to move to less central areas, then towards the suburbia. Outside the late Republican walls new metallurgical districts emerged, which seem to be connected to the main roads leading to and leaving the town. These ateliers were connected with Via Romagnosi, Via Croce Rossa and Piazza della Scala along the *cardo maximus* and the road leading towards today Lecco. Other forges were in the suburbium of Via Puccini. A forge was in Via San Vincenzo along the road to Abbiategrasso. In addition, in the suburbium where today there is one of the courtyards of Università Cattolica there were forges.

It is very important to point out that the developments from the 1st to the 2nd century AD rather than being a crisis phaenomenon show a shift and the emergence of a new and large metallurgical center in the area of Via Rugabella – Piazza Erculea – Corso di Porta Romana – Piazza San Nazaro. Here there were forges but above all, there was a mass production of copper and brass objects and of copper alloys mirrors.

References

Anderson, T.J., Agustoni C., Duvauchelle, A., Serneels, V. and Castella, D., 2003. *Des artisans à la campagne. Carrière de meules, forge et voie gallo-romaines à Châbles (FR). Archéologie Fribourgeoise,* 19. Fribourg: Academic Press Fribourg.

Anderson, T.J. and Serneels, V., 2004. La forge de Châbles-Les Saux (Canton de Fribourg, Suisse). In: M. Mangin, ed. 2004. *Le fer.* Collection "Archéologiques" dirigée par Alain Ferdière. Paris: Édition Errance. pp.98-99.

Barzanò, A., 2015. Il quadro storico. In: A. Ceresa Mori, ed. 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione*, *Notizie Archeologiche Bergo-*

mensi, 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.11-36.

Bauvais, S. and Fluzin, Ph., 2014. Organization of Forging activities in Northern Paris basin agglomerations (France) during the Final La Tène. In: B. Cech and Th. Rehren, eds. 2014. *Early Iron in Europe. Monographies Instrumentum*, 50. Montagnac: Éditions Monique Mergoil. pp.133-146.

Berranger, M., Duval, A. and Serneels, V., eds, 2014. *L'organisation spatiale des ateliers de travail du fer (VII^e-I^er siècle av. J.-C.).* Compte-rendu synthétique de deux journées d'étude tenues les 2 et 3 avril 2009 à Bibracte. V. Guichard, ed. 2014. Études sur Bibracte 2. Glux-en-Glenne: Bibracte. pp.275-314.

Berranger, M. and Fluzin, Ph., 2014. Levroux "Les Arènes" (Indre-France). Organization and specialization of post-reduction activities in an open agglomeration of the Late Iron Age (2nd century-beginning of the 1st century BC). In: B. Cech and Th. Rehren, eds. 2014. *Early Iron in Europe. Monographies Instrumentum*, 50. Montagnac: Éditions Monique Mergoil. pp.117-132.

Casini, S. and Tizzoni, M., 2015. Via Moneta: analisi culturale delle fasi preromane. In: A. Ceresa Mori, ed. 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione. Notizie Archeologiche Bergomensi*, 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.69-176.

Casini, S. and Tizzoni, M., 2015a. La produzione ceramica preromana: analisi delle forme. In: A. Ceresa Mori, ed. 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione. Notizie Archeologiche Bergomensi*, 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.177-266.

Ceresa Mori, A., ed., 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione*, *Notizie Archeologiche Bergomensi,* 23. Bergamo: Civico Museo Archeologico di Bergamo.

Ceresa Mori, A., 2015a. Lo scavo. In: A. Ceresa Mori, ed. 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione. Notizie Archeologiche Bergomensi*, 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.37-67.

Ceresa Mori, A. and Cucini, C., 2012. Un'officina di bronzista e la produzione di ottone e di specchi a Mediolanum nel I-II secolo d.C. In: C. Cucini, ed. 2012. *Acta mineraria et metallurgica. Studi in onore di Marco Tizzoni*, *Notizie Archeologiche Bergomensi,* 20. Bergamo: Civico Museo Archeologico di Bergamo. pp.205-224.

Cicero, *Pro Marco Fonteio Oratio*. Loeb Classical Library. Cambridge, MA, Harvard University Press 1989.

Cucini, C., 2015. Il quartiere celtico degli artigiani del metallo di Mediolanum. In: A. Ceresa Mori, ed. 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione. Notizie Archeologiche Bergomensi*, 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.387-450.

Cucini, C. and Riccardi, M.P., 2015. Analisi di manufatti e scarti metallurgici di epoca celtica. In: A. Ceresa Mori, ed. 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione. Notizie Archeologiche Bergomensi*, 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.451-459.

Cucini, C. and Tizzoni, M., 2001. Studio degli scarti metallurgici. In: G.P. Brogiolo and L. Castelletti, eds. 2001. *Archeologia a Monte Barro II – Gli scavi 1990-97 e le ricerche al S. Martino di Lecco.* Oggiono: Consorzio Parco Monte Barro. pp.273-279.

Danielisovà, A., 2014. Iron making in Late Iron Age Bohemia. Case studies from bohemian oppida and their hinterlands. In: M. Berranger, A. Duval and V. Serneels, eds. 2014. *L'organisation spatiale des ateliers de travail du fer (VIIe-Ier siècle av. J.-C.). Compte-rendu synthétique de deux journées d'étude tenues les 2 et 3 avril 2009 à Bibracte. V. Guichard, ed.* Études sur Bibracte, 2. Glux-en-Glenne: Bibracte. pp.304-305.

Diodorus the Sicilian. *The Historical Library in fifteen books.* London 1814 (reprint London: Forgotten Books, 2016).

Ducreux, F., 1999. Les structures. In: P. Chardron-Picault and M. Pernot, eds. 1999. *Un quartier antique d'artisanat métallurgique à Autun. Le site du Lycée Militaire*, *Documents d'Archéologie Française,* 76. Paris: Éditions de la Maison des Sciences de l'Homme. pp.189-195.

Fedeli, A.M. and Sartori, A., 2015. Stele funeraria multipla con testa ritratto da Milano. In: L. Malnati, and V. Manzelli, eds. 2015. *Brixia. Roma e le genti del Po. Un incontro di culture. III-I secolo a.C.* Catalogo della mostra, Brescia, Museo di Santa Giulia. Firenze-Milano: Giunti Industrie Grafiche. pp.269-270.

Fichtl, S., 2013. Les agglomerations gauloises de la fin de l'âge du Fer en Europe celtique (IIIe-Ier siècle sv. J.-C.). In: D. Garcia, ed. 2013. *L'habitat en Europe celtique et en Méditérranée préclassique. Domaines urbains.* Paris: Édition Errance. pp.1-25.

Fluzin, Ph., 2006, Premiers résultats des études métallographiques concernant les masses de métal brutes. In: M. Tizzoni, C. Cucini and M. Ruffa, eds. 2006. *Alle origini della siderurgia lecchese. Ricerche archeometallurgiche ai Piani d'Erna.* Lecco: Musei Civici di Lecco. pp.129-146.

Fluzin, Ph., Berranger, M., Bauvais, S., Pagès, G. and Dillmann, Ph., 2012. An archaeological and archaeometrical approach of ferrous semi-products: typology, quality and circulation. In: C. Cucini, ed. 2012. *Acta mineraria et metallurgica. Studi in onore di Marco Tizzoni*, *Notizie Archeologiche Bergomensi,* 20. Bergamo: Civico Museo Archeologico di Bergamo. pp.195-204.

Forrières, C., Petit, J.P. and Schaub, J., 1987. *Étude de la métallurgie du fer du vicus gallo-romain de Bliesbruck (Moselle).* Notes et Monographies Techniques n. 22. Paris: Éditions du Centre National de la Recherche Scientifique.

Grassi, E. M., 2016, *L'artigianato metallurgico nella Cisalpina Romana: i casi di Milano e Verona.* Roma: Scienze e Lettere.

Guillaumet, J.P. and Labaune, Y, 2011. Les activités artisanales de Bibracte et d'Autun: une pérennité des savoir-faire. In: M. Reddé, Ph. Barral, F. Favory, J.P. Guillaumet, M. Joly, J.Y. Marc, P. Nouvel, L. Nuninger and Ch. Petit, eds. 2011. *Aspects de la Romanisation dans l'Est de la Gaule*, *Collection Bibracte*, 21. Glux-en-Glenne: Bibracte. pp.895-906.

Kasprzyck, M. and Labaune, Y., 2003. La gestion des déchets à Augustodunum (Autun, Saône-et-Loire) durant l'époque romaine: les données archéologiques. In: P. Ballet, P. Cordier and N. Dieudonné-Glad, eds., 2003. *La ville et ses déchets dans le monde romain: rebuts et recyclages*. Actes du Colloque (Poitiers, 19-21 septembre 2002). Montagnac: Éditions Monique Mergoil. pp.99-116.

Mangin, M. and Fluzin, Ph., 2006. La métallurgie du fer chez les Mandubiens et les Lingons (Haut-Auxois et region des Sources de la Seine, Côte-d'Or): un artisanat de qualité. In: L. Baray, ed. 2006. *Artisanat, société et civilization: homage à Jean-Paul Thevenot*. Dijon: Revue d'Archéologie de l'Est, 24ème suppl. pp.523-538.

Mangin, M., Fluzin, Ph., Courtadon, J.L. and Fontaine, M.J., 2000a. *Forgerons et paysans des campagnes d'Alésia (Haut-Auxois, Côte-d'Or) Ier siècle avant – VIIIe siècle après J.-C.* CRA Monographies, 22. Paris: CNRS Editions.

Mangin, M., Courtadon, J.L., Fluzin, Ph. and De Laclos, E., 2000b. *Villages, forges et parcellaires aux Sources de la Seine. L'agglomération antique de Blessey-Salmaise (Côte-d'Or)*. Annales Littéraires de L'Université de Franche-Comté. Série "Environnement, Société, Archéologie", 699. Marmagne: Presses Universitaires franc-comtoises.

Melillo, L., 2016. Cassaforte con sacrificio a Giove. In : C. Bertelli and G. Bonsanti, eds. 2016. *Restituzioni 2016. Tesori d'arte restaurati*. Catalogo della mostra. Gallerie d'Italia, Piazza Scala, Milano. Venezia: Marsilio. pp.62-67.

Monteil, M., Barberan, S., Bel, V. and Hervé, M.L., 2003, Dépotoirs domestiques et déchets artisanaux: l'exemple de Nîmes (Gard) au Haut-Empire. In: P. Ballet, P. Cordier and N. Dieudonné-Glad, eds., 2003. *La ville et ses déchets dans le monde romain: rebuts et recyclages*. Actes du Colloque (Poitiers, 19-21 septembre 2002). Montagnac: Édition Monique Mergoil. pp.121-131.

Pagès, G., 2008. *La métallurgie du fer en France méditérranéenne de l'Antiquité au début du Moyen Âge: jalons d'une approche intérdisciplinaire*. PhD. University Paul Valéry, Montpellier.

Paris, P. and Berranger, M., 2014. Un autre atelier de forge à Bibracte, au pied du bastion Sud de la Porte du Rebout. In: M. Berranger, A. Duval and V. Serneels, eds. 2014. *L'organisation spatiale des ateliers de travail du fer (VIIe-Ier siècle av. J.-C.)*. Compte-rendu synthétique de deux journées d'étude tenues les 2 et 3 avril 2009 à Bibracte. Études sur Bibracte 2. Glux-en-Glenne: Bibracte. pp.302-304.

Pernot, M., 1998a. Des ateliers métallurgiques près de la Porte du Rebout. In: K. Gruel and D. Vitali, eds. 1998. *L'oppidum de Bibracte. Un bilan de onze années de recherche (1984-1995). Gallia*, 55. Paris. pp.52-60.

Pernot, M., 1998b. L'organisation de l'atelier du bronzier. In: C. Mordant, M. Pernot and V. Rychner, eds. 1998. *L'atelier du bronzier en Europe du XXe au VIIIe siècle avant notre ère. Du minerai au métal, du métal à l'objet. Documents Préhistoriques,* 10. Paris: CTHS. pp.107-116.

Perring, D., 1991. Lo scavo di Piazza Duomo: età romana e altomedievale. In: D. Caporusso, ed. 1991. *Scavi MM3. Ricerche di archeologia urbana a Milano durante la costruzione della linea 3 della metropolitana 1982-1990, vol. 1*. Milano: Edizioni ET. 4 voll. pp.105-161.

Plutarch, *Lives.* Loeb Classical Library. Cambridge, MA, Harvard University Press 1989.

Rapi, M., 2015. Gli ornamenti metallici di età preromana. In: A. Ceresa Mori, ed., 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione. Notizie Archeologiche Bergomensi,* 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.339-344.

Rottoli, M., 2015. I materiali edilizi. In: A. Ceresa Mori, ed., 2015. *Lo scavo di via Moneta a Milano (1986-1991). Protostoria e romanizzazione. Notizie Archeologiche Bergomensi,* 23. Bergamo: Civico Museo Archeologico di Bergamo. pp.461-471.

Sacchi, F., 2012. *Mediolanum e i suoi monumenti dalla fine del II secolo a.C. all'età severiana*. Contributi di Archeologia, 6. Milano: Editore Vita e Pensiero.

Schäfer, A., 2001. A Late Celtic Bronze Foundry from the Oppidum of Kelheim, Lower Bavaria, Germany. In: *International Conference Archaeometallurgy in Central Europe III. Herľany, Slovakia, 11-14.9.2000. Acta metallurgica Slovaca (special issue),* 7,2. pp.190-203.

Schucany, C., 1994. Les forges de la villa rustica de Biberist-Spitalhof, Suisse. In: M. Mangin, ed. 1994. *La sidérurgie ancienne de l'Est de la France dans son context européen. Archéologie et archéometrie. Actes du Colloque de Besançon, 10-13 novembre 1993. Annales Litéraires de l'Université de Besançon,* 536. Paris: Diffusion Les Belles Lettres. pp.143-158.

Schwab, R., 2014. Resources and recycling: Copper Alloys and Non-Ferrous Metalworking in the Oppidum of Manching (Germany). In: E. Pernicka and R. Schwab eds. 2014. *Under the Volcano. Proceeding of the International Symposium on the Metallurgy of the European Iron Age (SMEIA) held in Mannheim, Germany, 20-22 April 2010.* Rahden/Westfalen: Leidorf. pp.175-188.

Senn, M., Schreyer, S. and Serneels, V., 2014. An urban fine smithing quarter in the oppidum of Rheinau (Canton Zürich, Switzerland). In: E. Pernicka and R. Schwab eds. 2014. *Under the Volcano, Proceed. Of the International Symposium on the Metallurgy of the European Iron Age (SMEIA), Mannheim, 20-22 April 2010.* Rahden/Westfalen: Leidorf. pp.103-120.

Serneels, V. and Chardron-Picault, P., 1999. Les vestiges sidérurgiques. In: P. Chardron-Picault and M. Pernot, eds. 1999. *Un quartier antique d'artisanat métallurgique à Autun. Le site du Lycée Militaire. Documents d'Archéologie Française*, 76. Paris: Éditions de la Maison des Sciences de l'Homme. pp.201-213.

Serneels, V., Merluzzo, P. and Leroy, M., 2004. Les activités de forge: le travail du metal. In: M. Mangin, ed., 2004. *Le fer*. Collection "Archéologiques" dirigée par Alain Ferdière. Paris: Édition Errance. pp.81-112.

Serneels, V. and Perret, S., 2003. Quantification of smithing activities based on the investigation of slag and other materials remains. In: Associazione Italiana di Metallurgia, ed. 2003. *Archaeometallurgy in Europe. 2003. International conference: archaeometallurgy in Europe, 24-25-26 September 2003. Milan, Italy: proceedings*. Milano: Associazione Italiana di Metallurgia. pp.469-478.

Serneels, V. and Perret, S., 2007, *Les scories de forge de La Tène finale*. In: T.J. Anderson and D. Castella, eds. 2007. *Une* *ferme gauloise* à Courgevaux (Fribourg, Suisse). *Archéologie fribourgeoise/Freiburger Archäologie,* 21. Fribourg: Academic Press Fribourg. pp.135-152.

Sievers, S., 1993. Das Oppidum von Manching. *Archäologie in Deutschland,* 3, p.32-35.

Tizzoni, M., 1997. L’officina fusoria. In: A. Ceresa Mori, ed. 1997. *Dal cantiere alla storia. Lo scavo di via Puccini a Milano*, n. 5. Milano.

Tizzoni, M., 2014. Da Belloveso alla Ca’ dell’Inferno. Contributo alla storia della metallurgia milanese. *Notizie Archeologiche Bergomensi,* 22. Bergamo: Civico Museo Archeologico di Bergamo. pp.219-280.

Tizzoni, M., Cucini, C. and Ruffa, M., eds. 2006. *Alle origini della siderurgia lecchese. Ricerche archeometallurgiche ai Piani d’Erna*. Lecco: Musei Civici di Lecco.

Author

Costanza Cucini
Université de Technologie Belfort Montbéliard
Laboratoires “Métallurgie et Cultures” UMR 5060, CNRS, IRAMAT
F-90010 BELFORT Cedex
costanza.cucini@libero.it