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

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Abstract
This paper deals with the metallurgical activities in the Celtic metalworkers’ district of Mediolanum. Its development began 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 workshops are both previous and contemporary to the Romanization. They were built with perishable materials and according to the local building technique. 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 Cereta Mor. 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.

Abstract
This paper deals with the early phases of the metallurgical 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 Boni 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 northern 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, 2015).

Keywords
Iron, copper metallurgy, oppidum, Gaulish-Roman
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 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.

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

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The complex relationship between the Roman Re-
public and these independent neighbouring territories and the interest of the Romans to trade with them. These territories outside the Roman borders were the destina-
tion of many Latin merchants, whose travels anticipated the military conquests by far. The merchants who oper-
ated in areas under Roman cultural influence could trade much more easily compared to their competitors. For ex-
ample, those trading with Southern Iberia (Posidonius in Diodorus V, 36, 3) or with Gallia Narbonensis (Cicero, Pro Fonteio) (Casini and Tizzi, 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 Pro-
vince. Julius Caesar used Mediolanum as his headquar-
ters 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 Mediolu-
num there was a rich-pro-Roman indigenous ruling class and premises appropriate enough to host Julius Caesar and his entourage.

The Roman citizenship was granted to the Insubres in the year 49 BC and Mediolanum became Municipium civitatis 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 Panni d’Erna (Lecco) (Tizzoni, Cuccioni and Ruffa, 2006). At this site (1st-1st century BC-second half of the 1st century AD), contemporaneous to the metallurgical district of via Moneta, it is possible to observe the transition from Celtic to the Ro-
man culture in Cisalpine Gaul. Here we can observe the transition from the large domed furnaces of Celtic tra-
dition 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 Panni 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 Na-\ntional Archaeological Service has dug a 2nd-1st centu-
ry BC small settlement with a forge. This atelier had a hearth similar to that of Panni d’Erna. Possibly semi-finish-
ished 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 Switzer-
land, for example at Courgevaux (Freiburg) (Serneels and Perret, 2007).

Further informations are only available again about the early imperial period.

The metallurgical district of Via Moneta

The earliest artisans’ district of Mediolanum (Via Mon-
eta) developed during the transitional period between the local “proto-urbanization” and the city planning of Romanization (Cucini, 2015). A group of metal work-
ing artisans formed an intra muros district at the set-
tlement’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 artisans witness the metallurgical development over a long period of time beginning between Golasecca III A3 –LT Ba (beginning of the 4th century BC) and last-
ing 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) End of the 3rd century BC to 1st century AD.

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The metallurgical activities 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 area of the 1st century BC in Via Fratelli Gabba. All these finds belong 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 Mori, 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 (Vitrivius’ 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 metallic 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

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 glarata 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 defense 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 6th-middle 4th 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.

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Figure 2. Plan of the metallurgical 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 tided 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 build-ings of unknown use, they could have been the artisans’ dwellings.

Iron working ateliers

In the district of Via Moneta various metallurgical 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).

Metallographic studies demonstrate that 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, 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 Ducruex (1999, pp.189-192) for the copper metallurgy ateliers of Autun-Augusto-Ittuno 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 reden-ning 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 clas-sified 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) and oval (50 x 80, 70 x 100 cm) pits, they may be, but not always, carefully made and are strongly redenilled 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 op-pidum of Vernon-Le Camp de Mortagine (Bauvrais and Fluzin, 2014, pp.135, 141, Fig. 13) and in Provence at Olbia in a period dated between 40- and 30 BC (Pages, 2008, p.89). Also, during the early centuries of the Ro-man Empire. For example: at Lunel-Viel near Ambrus-sum in Languedoc-Roussillon (Pages, 2008, pp.95-97), at the Roman-Gaulish village of Blessey (Côte-D’Or) (Mangin et al., 2000b, pp.236-238), in the metallurgi-cal district of Lycée Militaire of Autun-Augusto-Ittuno (Serneels and Chardon-Picault, 1999, pp.206-209), at the Roman-Gaulish village of Blessey in Forez (Foires, Petit and Schloopp, 1987, p.13).

Similar bowl-shaped hearths were found in a sub-ur-ban 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 Milano 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. Hearth formed by a simple reddened area at ground level (Figure 4 A). A shallow (5-10 cm), squat, 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 redenilled. Nevertheless, it is difficult to un-derstand 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 men-tioned, 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 Aloes (Haut-Aus-sis, Côte-D’Or), where dozens of iron and bronze 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).
A served example. Apparently, it was a rectangular pit. The central hearth was formed by two pieces of reddened clay and radial clay formed the other. Similar finds are from: Biberist (Schaub, 1987, pp.11, 13), Autun-Augustodunum in the Lycée Militaire district (Sernaels and Chardon-Picault, 1999, pp.208-210, Fig. 170). In Italy at the metallurgical site of Piani d’Erna (Lecco) an area of reddened clay (di-
ameter 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 (C3) (Schucany, 1994), Bliesbruck (Forrières, Petit and Schaub, 1987, pp.11, 13), Autun-Augustodunum in the Lycée Militaire district (Sernaels and Chardon-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 Sernaels, 2004, pp.98-99), at Autun-Augustodunum at the Lycée Militaire site (Sernaels and Chardon-Picault, 1999, p.210). In Milan in Via Pucinni 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 am-

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 (Sernaels and Chardon-Picault, 1999, pp.208-210, Fig. 170). In Italy at the metallurgical site of Piani d’Erna (Lecco) an area of reddened clay (di-
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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 acerometallurgical study of the slags has shown (Tizzoni, 2014, pp.230, 254-262) that ashes were added as fluxes during soldering and other operations. Water (Tizzoni, 2014, pp.230, 254-262) that ashes were added 2nd-early 1st century BC) the belly of an 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 Outbria a forge (40/30 BC-20 AD) the bottom of an amphora filled with sand (Pagès, 2008, p.89), at Blisbruck, 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 (Ducorreux, 1999, p.193; Serneri and Chaudron-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 Roman-Gaulish settlements (Kasparyk 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. 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 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. 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.

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Figure 6. Samples of iron waste from 3rd-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 medium 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 even smaller and formed by magnetite and wistite. 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.

### 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 2nd 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 by magnetite and wistite was found; the crucibles used for this purpose were of appropriate dimensions. Presently there are no accurate and in-depth analyses 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 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-lau of Piani d’Erma (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’Erma 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.

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

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

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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.

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

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

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

Figure 10. Copper-alloy waste, photo and drawing, from Cucini (2015, Fig. 31 and 34).
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 Machning (Schwab, 2014).

The products and the copper alloys composition

The artisans’ district of Via Moneta: conclusions

The district of Via Moneta in Milan is an exceptional example of a Celtic and Roman-Gaulish metallurgical district in Casalpiana 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 glarea, an important communication route. Comparable ateliers built along a ditch can be found in oppida of Zavist and Stradonice in Bohemia (Danzírová, 2014), at Bibracte, at Condé-sur-Suippe and at Villedenouve-Saint-Germain (Fichtl, 2013). At Marching the oppidum’s plan possibly mirrors the functions of the different districts. In the op- pidum’s central part of Altenfeld there was the arti- sans’ district along the decumanus’ central part (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 metal- lurgical 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 Tizzi, 2015).

The archaemetallurgical study of the forgings 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 heaths 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 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 Machning (Schwab, 2014).

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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).
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 Naunheim 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 Lecino-Oltra. Other were in the suburbium of Via Puccini. A forge was in Via San Vincenzo along the road to Abbatigrasso.

In addition, in the suburbium where today there is one of the courtyards ofUniversità Cattolica there were forges. It is very important to point out that the 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 Alexia (Mangin, et al., 2000a, pp.88, 91-93; Mangin and Fluzin, 2006), at Bibracte (Pernet, 1988a; Guillaumet and Labaune, 2011; Berranger, Duval and Serneels 2014), at Conde-sur-suippe and Saint-Nicolas-le-Bac (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 Leuvox-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 (Fichelt, 2013). At the oppidum of Kelheim there was a bronze foundry at the middle of the 1st century BC (Schäfer, 2001).

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