Working Together and Learning Together: The Study of the Metallurgical Remains of San Tommaso, Pavia, Italy

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Multi-disciplinary classes; teaching multidisciplinarily; multi-disciplinarity in archaeometallurgy

Abstract

The metallurgical remains of San Tommaso, Pavia were used as teaching collections for a multi-disciplinary archaeometallurgy class held by the first time in the academic year 2016/2017 at the University of Sassari. This paper, written by the lecturing academic, the academic advisor, and some of the students attending the course, wants to bring to the archaeometallurgical community some of the observations and reflexions on this teaching and learning experience. The varied metallurgical assemblage recovered from the excavation in 2013 of the Monastery of San Tommaso (Pavia) is a very useful teaching tool. In all, 23 samples were analysed and are presented in this paper from at least six different metallurgical processes: cupellation, silver recovery, iron making (by the direct and indirect method), copper alloying and casting. This variety also poses more complex questions for the archaeological/historical re-contextualisation of the findings which require a strong interaction between archaeologists and scientists in order to ensure the "Pavia"most plausible reconstruction of events. In particular, we aim at introducing the importance of different perspectives in "questioning" the materials and in turn the scientific results.

While presenting the results of the archaeometric investigations the main aim of the paper is to introduce the idea of the importance of multi-disciplinary teaching in archaeometry, more specifically in archaeometallurgy, early on in the academic development (master or even undergraduate) instead of being the result of research at a later stage (PhD or even post-doc). The experience here presented, shows that differences in languages and perspectives and peer-to-peer teaching offers an enhanced learning tool.

Introduction

The word archaeometallurgy already includes a multiplicity of disciplines. However, through time it has become rather obvious that not only archaeology and metallurgy are involved, but also geochemistry, geology, mining geology, mineralogy, material and conservation science, history and economic history. All of which need to be embraced within the discipline to create a varied multi-disciplinary landscape able to contextualise chemical data, reconstruct environmental challenges and capture innovative responses. Seeing archaeometallurgy as a discipline aimed at the reconstruction of innovation, we can then easily portray the possibility of incorporating it in a much larger landscape including modern engineering, economics and politics. To this end, there is a need to discuss how can this multi-disciplinarity be achieved and how and when can it be integrated into the academic curriculum. Archaeometallurgists are hybrid professionals, integrating archaeology and science; however, as the discipline becomes more complex, this complexity needs to be present in the academic curriculum at an early stage. While one professional cannot be an expert in many disciplines, a team of professionals can. In this paper, we argue that a multi-disciplinary topic, such as archaeometallurgy requires a multi-disciplinary teaching and research environment with a varied group of students/scholars with different backgrounds to ensure that peer-to-peer teaching and multi-perspective questioning transforms the classroom in a multi-disciplinary working group.

Multi-disciplinary team versus hybrid professionals

Despite more than 40 years of cross-disciplinary practice in universities there is still a lack of consensus about what the terms ‘inter-disciplinarity’, ‘multi-disciplinarity’ and ‘trans-disciplinarity’ actually mean (McEwen, et al., 2009, pp.15-17).

One distinction proposes that ‘multi-disciplinarity’ describes situations in which several disciplines cooperate but remain unchanged, whereas in ‘inter-disciplinarity’ there is an attempt to integrate or synthesise perspectives from several branches of knowledge. Trans-disciplinarity, on the other hand, has been taken to involve a transgression or transcendence of disciplinary norms, sometimes ‘in the pursuit of a fusion of disciplines, an approach oriented to complexity or real-world problem-solving’ (Lawrence and Despres, 2004).

The higher education curriculum tends to be highly discipline-based, designed to deliver a set of subject-based outcomes. Research, on the other hand, is becoming increasingly interdisciplinary in nature, but learning and teaching often fails to keep pace. Furthermore, it is important to note here that when we talk about broadening the skill sets of tomorrow’s graduates we are not advocating replacing highly trained specialists with a cohort of generalists (Lawrence and Despres, 2004).

If we then decide to use the definition of multi-disciplinarity, we are struck by the idea that archaeometallurgists are a variety of scholars from different disciplines looking at the history of metallurgy from their different perspectives, and only a team could really generate a holistic understanding of a particular site, regional development, or global trend.

Hence, while a fully hybrid professional figure seems to be necessary to act as a liaison between the different disciplines, this hybrid figure does not really exist in the sense that each member of the team might have a wider vision, but they would still remain looking at the problem from their own perspective. However, a partial hybridisation is actually required to foster the skills to understand each other’s languages and comprehend each other’s questions in order to select the appropriate methods within our own discipline to obtain the most comprehensive set of data and its consequent interpretation.

Furthermore, looking also at the outside world, skills that are increasingly valued by companies in all sectors include creativity, flexibility and adaptability, communication and negotiation skills, and management and leadership skills that can be deployed within teams and projects, as well as within organisations (Tether, et al., 2005). The idea of multi-skilled personnel further the idea of multi-disciplinarity as an ability to work and create knowledge with members of a team from different disciplines. This also points towards the potential increase in employability of students within the archaeometallurgical field or outside it.

The design of multi-disciplinary teaching

An investigation conducted by HEFCE on multi-disciplinary teaching centres in the UK has shown how vital this type of teaching is for the UK socio-economic landscape.[1] Multi-disciplinary classes should be able to offer a new combination of skills, exposure to teams with different languages, different methodologies and different questions. Such design in education seems to respond to the wider requirements of archaeometallurgy as described above.

This paper will focus on the experimental design of the archaeometallurgy module developed by the first author at the University of Sassari in the academic year 2016/2017, where McKensey’s definition of “T-shaped people” was used to form a class of people: they specialised in their own discipline at undergraduate level, and moved within a multi-disciplinary class environment for the specific module of archaeometallurgy at master level. We will describe in the methodology chapter (section 4) on how many levels this multi-disciplinarity – which did not include only the students, but also the lecturer and academic advisor – was achieved. The scope for students to learn from each other whilst expanding their horizons is potentially enormous. However, this also raises some significant practical problems. In particular, module leaders need to be constantly aware of the diversity of their students, in terms of experience and familiarity with different forms of assessment. A chemistry student may have less experience of writing essays than a history student, but would be more familiar with statistical or mathematical approaches.

The main aims of an archaeometallurgy multi-disciplinary class are to:

- Develop a common language
- Enjoy peer-to-peer explanation and discussion
- Experience research methods

This experiment started with the idea of directly using research methodology in the classroom, fostering the strategy developed by the Curriculum Innovation programme at Southampton University (Smith, 2013): “Curriculum innovation is also about the willingness to embrace change and to recognise the opportunities offered by burgeoning educational technologies and the changing landscape of academic research”.

The results of the experiment were extremely interesting, and even more interesting was the continuous discussion with the students on the topic of multi- or inter- disciplinarity.

However, from a wider angle more questions remain. How is multi-disciplinary teaching in archaeometallurgy – and, more widely, in archaeometry – impacting not only on the disciplinary sector, but also, and to a larger extent, on the wider horizon of heritage management, improvements in local economy and economic understanding at regional, national, European and/or global level? Can the creation of the multi-disciplinary thinker in archaeometallurgy contribute to the solving of the socio-economic challenges we are facing globally? Starting from climate change, all the way through to novel sustainable innovation, where is the role of archaeometallurgy, and how are the skills generated within its multi-disciplinary framework important to policy-makers, economy and social innovation? Would the development of archaeometallurgy finally support the creation of a more sustainable environment?

Multi-disciplinarity in the Classroom

Collaboration among experts from different disciplines has always been the key success factor in scientific research. In recent years in archaeology, technological innovation has been increasingly applied in excavations and used for studying ancient materials. Indeed, academic courses nowadays include the teaching of hard science subjects and training seminars on new technologies with the aim of giving to future archaeologists a basic knowledge, which will help them to interact with specialists in the most effective way. For this reason, hybrid skilled students are highly valued and have more of a chance than others to succeed in the academic field.

The intermingling of humanities and hard sciences is the key to renewing a research field, such as Archaeology, which in some countries is still very conservative. In today's Italy, it is still considered by many academics as a synonym of art history, or as a discipline dependent on the study of historical sources. However, the past 20 years of archaeometallurgical publications, and the research we are describing in this paper, demonstrate that through real dialogue between students of the humanities and natural scientists we can reach new holistic goals in research, and more a comprehensive understanding.

Many researchers consider a multi-disciplinary team more efficient than a monodisciplinary one, because the roles and responsibilities of each member are clear and ensure better co-ordination of assignments, and it avoids duplication of work and increases the number of points of views from which the problem is tackled.

The first step of the research group is learning to work together: the members have to learn how to communicate with each other in order to share the results of their own research, by creating a common language in order to achieve the positive synergy within the team.

The difficulties begin when a set of individuals works have to come to a synthesis. Each scientific contribution starts with its own methodological perspective and specific research interest. The confrontation of ideas stimulates creativity among team members: the debating inspires new questions, providing useful tools to find new solutions and to focus on what are the limits of one's own work, defining more precisely the goals of own research. This collective brainstorming process leads to change of previous interpretations towards better and/or new interpretation of the facts.

The study of the materials from San Tommaso in Pavia was carried out during the hours dedicated to laboratory work of the archaeometallurgy module held in the Department of Chemistry of the University of Sassari by the first author, Researcher at Brunel University London. The group included archaeologists, geo-archaeologists and chemists, working together as a research team where the members also had different levels of education and research experiences (from PhD level to undergraduate). Firstly, the students were presented a series of frontal lessons dedicated to the fundamentals of archaeometallurgy and a series of case studies focused on the working of different metals. The lectures were then followed by a laboratory activity focused on metallurgical debris. Dr Grassi provided the samples, along with macroscopic pictures, a preliminary identification of the remains and an archaeological background, in order to facilitate the archaeometallurgical investigation. The strategy used was to "open" the assemblage for the first time with the student without prior evaluation of the samples, in order to follow a "normal" research routine, following the conviction that there is a lot to learn from what the lecturer does not know, since this brings the "how do I find it out?" to life.

Observation and analysis were carried out at the „CESAR" laboratory of the Department of Chemistry, University of Sassari.

Students from both the Archaeology and Chemistry departments participated in the course, whose backgrounds of knowledge, language and "forma mentis" were highly heterogeneous. The interaction between such different competencies determined a situation that was not easy to coordinate, since each field of knowledge corresponded to a different way of perceiving the teaching and consistently came up with questions of a very different nature, each responding to peculiar instances of the different disciplines, during both the frontal lecture and the laboratory time. Often, the pupils were asked to engage into peer to peer activities such as explanation of analytical techniques, software, physical or archaeological theories. They were put in an environment in which they could engage in direct discussion both with the lecturer and between each other.

Competences pertaining to the so-called „hard“ sciences encountering a subject most susceptible to speculation have created a new experience that has necessitated a recalibration in the transmission of the teaching itself, involving at the same time all participants in the effort to acquire a new approach to the discipline. Such a process has involved a number of challenges and generated a set of objectives to be achieved in order to successfully complete the educational process. The effort made to bridge the gap between the different disciplines led to the understanding of each other's language and point of view, developing a common knowledge accessible to all without diminishing the questions of colleagues from different fields, but taking the opportunity, through these, to build a deeper knowledge of one's own discipline. This condition is in fact one of the first and perhaps more interesting to have manifested itself during the development of the course, and even more in the many discussions that followed, through frequent skype calls between the students, the lecturer and Dr Grassi. It was interesting to observe how each of the students from different fields came up with questions and observations that showed how different aspects were considered useful and of interest to focus on. The sum of the questions raised provided a complete overview of all aspects of the problem debated, which enabled a thorough examination of the various options valid for its solution. In fact, what became more evident was the need for a debate, more than a frontal knowledge transfer from the lecturer. Debating options and ideas made the learning more challenging and widened the experience from the discipline to a more comprehensive knowledge building approach, more similar to pure research.

The result of this multi-disciplinary exercise was the creation of a multi-disciplinary group, in which all those who participated exchanged views, not without difficulty, having to create a shared vocabulary. This did not create a fully expressed hybrid professionalism, which would synthesizes in itself archaeological, chemical, and geological expertise, but on the contrary enhanced each discipline and their individuality creating the bridging skills to work within a multi-faceted team.

The result of this experience was the achievement of a new approach to research by young scholars.

The awareness that there are paths and tools not strictly related to one‘s discipline but that can be integrated with it, providing a most effective support if such tools are questioned in a precise and relevant way, was unequivocally a milestone. Furthermore, it cannot be neglected that for all involved this has been an occasion of profound human and professional growth.

WORKING TOGETHER = LEARNING TOGETHER

Benefits

1. Learning new languages
2. Have a larger pool of expertise
3. Embracing each other's methodologies
4. Creating a deeper and wider prospective
5. Create a young researcher with an awareness of what are the questions and what could be the answers within a multi-disciplinary environment

Challenges

1. Understanding each other's language
2. Seeing each other's point of view
3. Challenge one's knowledge to make the other understand
4. Do not attempt to create a hybrid professional figure
5. Do not diminish the questions of the colleagues from other disciplines, but use their questions to build awareness of your own discipline

Historical - Archaeological Introduction

The metalworking evidence that was used within this teaching experiment come from a development-led archaeological excavation carried out in 2013 in the complex of San Tommaso in Pavia (Northern Italy) (Figure 1).

The area of the excavation is located in the historic centre, in an area that was already part of the city during the Roman period, and features a rich and complex archaeological stratigraphy: due to its central location, it was never abandoned, but new buildings were constructed over the ruins of the older ones.

The earliest phases seem to belong to the Roman period: since the 1800s, building works and archaeolog-

Figure 1. The complex of San Tommaso, Pavia, now part of the University of Pavia, aerial picture (Google Earth).

ical investigations have brought to light several imposing structures, possibly belonging to a thermal complex (Arslan and Bossi, 1968; Saletti, 1989). These were partially dismantled during the early Middle Ages when, probably in the second half of the 9th century, the first church dedicated to San Tommaso was built.[2] Local medieval historian Opicino de Canistris remarks that San Tommaso is the *centrum civitatis* – thus highlighting its prominent location within the city – and that under it there is a "large and beautiful spring of water, covered by a great vault" (a Roman cistern? Part of the baths? – Lanzani, 1989.) Little is known regarding the earliest appearance of this church, which was refurbished in the early 13th century (Arslan and Bossi, 1968): in 1302, when the Dominicans bought it from its previous owners, the Benedictine nuns, it is described as "debole, vecchia ed angusta" (-weak, old and narrow- Andreolli Panzarasa, 1989). A new, larger and more splendid church was built between 1320, when the existing building was dismantled, and 1478, when the roof was completed. At the same time, over the course of the 14th century, the adjoining convent underwent several refurbishments. Enlargements and alterations were needed in order to accommodate the *Studium* (the earliest name of the University of Pavia), created in 1361. Several documents testify the activity of artisans (carpenters, masons, blacksmiths…), who transformed the cloisters into classrooms and lodgings (Andreolli Panzarasa, 1989).

In 1784 the convent was closed and its structures were heavily altered by G. Piermarini in order to house the city Seminary, which lasted a little over a century. In 1891 it was turned into a military barracks (Caserma Nino Bixio). At present, the structure belongs to the University of Pavia.

The finds of the most recent excavations are still being assessed and interpreted: the results will surely shed light on the nature of the earliest buildings and on the history of the monastic complex. At the moment, only the metalworking evidence has been investigated in depth. Most are from the medieval layers, with only a few pertaining to more recent periods.

Archaeometric Methodology and Results

The materials from San Tommaso in Pavia were chosen as teaching material for their wide diversity (Figure 2). A total of 23 samples showing macro-morphological differences were selected to ensure the investigation of a variety of metallurgical processes.

The results obtained indicate at least the following processes: cupellation; silver recovery; iron making (by the direct and indirect method); copper alloying and casting (Figure 3).

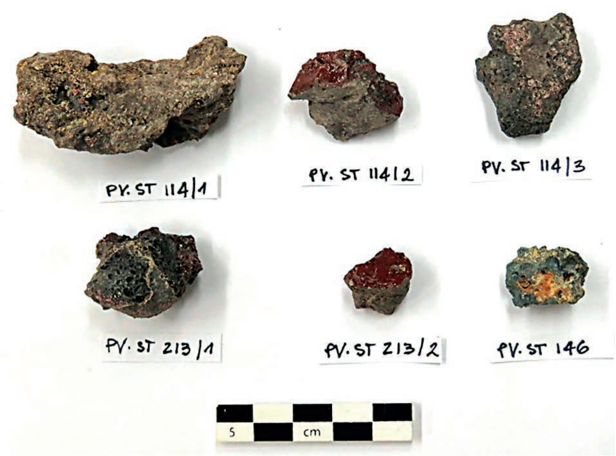


Figure 2. Example of the diversity of the metallurgical debris recovered at San Tommaso (Pavia). The investigation of the materials was performed using optical microscopy, X-Ray fluorescence, and scanning electron microscopy.

The assemblage indicates a complex and multi-faceted metallurgical landscape at the site, and raises several questions:

Is the area where the debris were found their primary depositional context, or were they moved to their final position afterwards (e.g. used a fill)?

How can we explain the presence of "industrial" processes such as direct iron making in an urban area? What was the reason for performing of all these tasks in this location? Where they performed parallel?

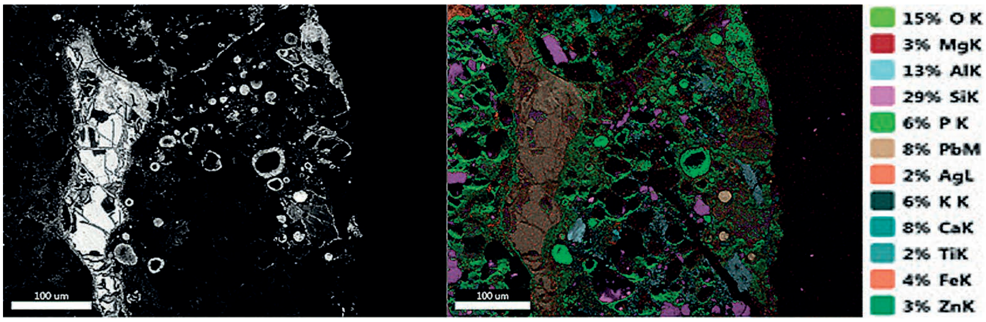
Can archaeology (pottery, stratigraphy) help in any way to identify which processes may have occurred in connection to the monastic complex?

The possibility of using chemical, archaeometallurgical, archaeological and historical tools and expertise together, allowed the team to think outside the box and start putting forward a working hypothesis. This paper gives an overview of the metallurgical finds but does not focus on it because in this case the materials are only used as the means to achieve a multi-disciplinary teaching/learning environment.

Conclusion and Re-contextualisation of the Results

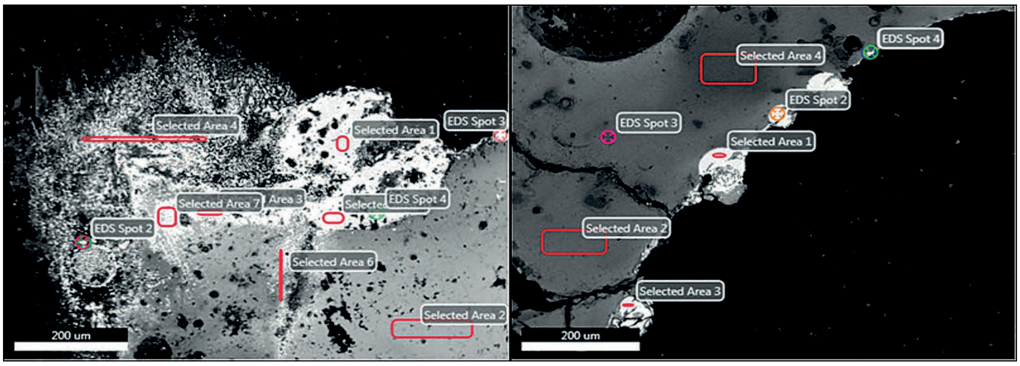
The archaeological materials discussed here were found in dump layers in the area of the former convent and church of San Tommaso. They consist of fragments of crucibles and slag that are residues of metalworking activities. The analyses show evidence of metallurgical

Figure 3. a) SEM image and elemental map of sample #20



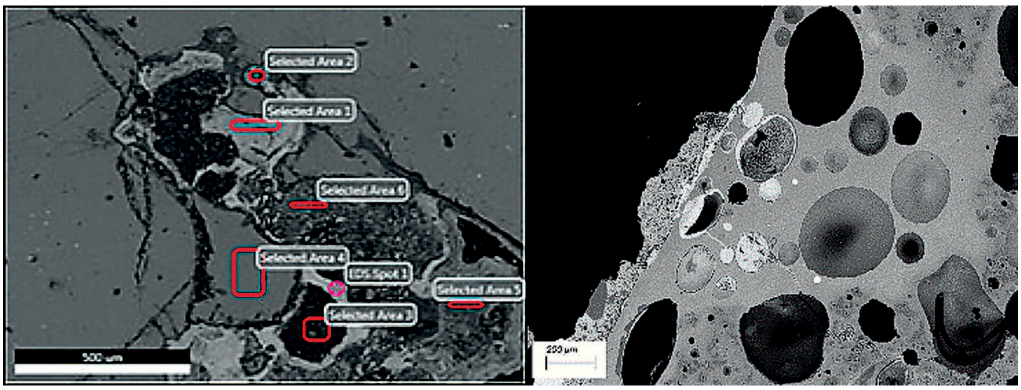
Cupellation
Sample #20
Fragment of furnace wall. The elemental map of the sample shows the characteristic presence of lead surrounded by droplets of silver metal within a phosphate phase. No other phosphorous enrichment was visible in the assemblage which seems to indicate that the phosphate phases detected here are not deriving from later uptake from the soil.

Figure 3. b) On the left images of sample #213/1, on the right images of sample #172



Silver recovery
Sample #213/1 (left)
Lead silicate matrix and lead / copper metal droplets. The composition and morphology of this slag seem to indicate the use of lead to collect silver from a copper/silver object.
Sample #172 (right)
Aggregation of silver droplets on the crucible wall. The areas around the silver prills are highly enriched in iron.

Figure 3. c) Amorphous silicatic matrix with iron prills in sample #146 (left) and #419/1 (right)

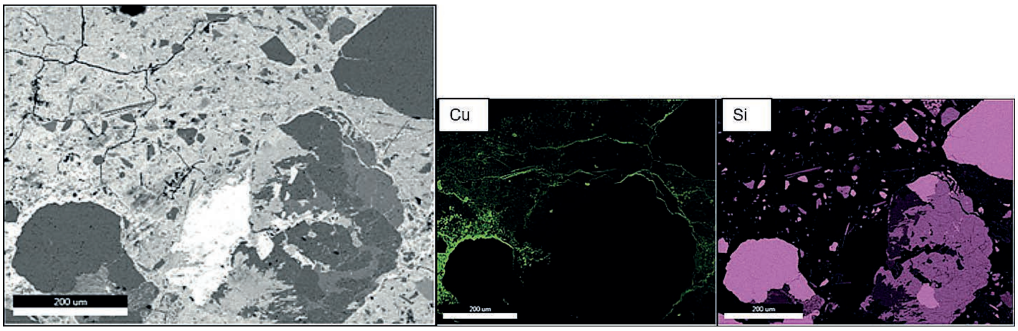


Iron making – indirect method
Macroscopic appearance: lumps of glassy material, bluish in colour
Sample #146 (left)
Amorphous silicate matrix with metal iron (at different stages of corrosion) trapped in the cracks
Sample #419/1 (right)
Amorphous silicate matrix with bubbles and prills of metal iron, sometimes with traces of phosphor.
All three samples are typical of iron making in blast furnace indicating high temperature (amorphous slags) and high vapour conditions (bubbles) as well as the presence of phosphorus typical of the carbon-rich steels deriving from this method.

Figure 3. d) Amorphous silicate matrix with iron metal and fluxes

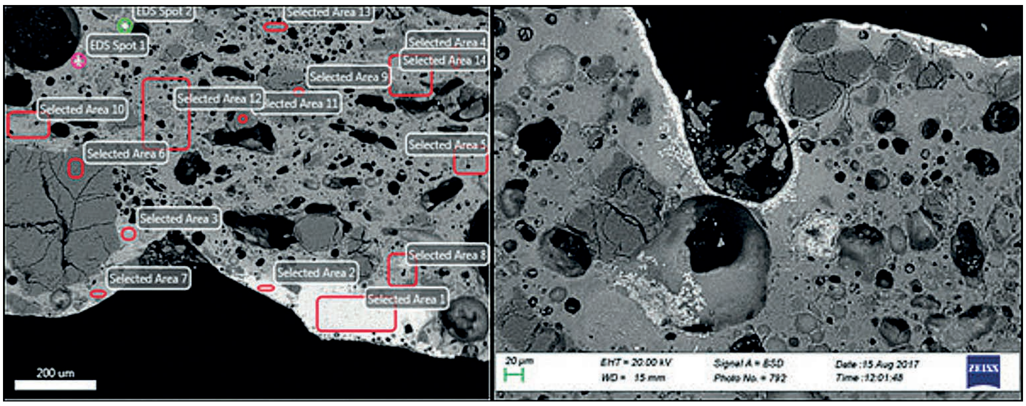
Iron making –direct method (bloomery)
Sample #420/2
Silicatic matrix containing quartz grains (left), iron metal (centre), iron oxide and calcium carbonate (right), often used as flux. This heterogenous fragment contains the final product (iron) as well as the raw materials: iron oxide (ore), quartz and calcium carbonate (fluxes). The morphology of the quartz grains seem to indicate addition to the charge, while the calcium carbonate might be the gangue of the ore.

Figure 3. e) Crucible ceramic matrix and elemental maps of sample #417



Copper casting
Sample #417
Ceramic matrix with dispersed angular quartz and aggregates of copper metal

Figure 3. f) Bronze and copper prills in crucible ceramic matrix



Copper alloying
Sample #80-2 (left) and #172A ((right)
#80-2: the crucible fragment shows large prills of copper metal, and bronze with a 3/2 Cu/Sn ratio on the surface of the crucible.
#172 A: the ceramic matrix of the crucible features bloating and fractured quartz grains due to thermal treatment, and a layer of tin oxide (white) on the surface.
Both crucibles contain prills with high tin, which is an indication that tin was added to copper metal in an alloying process.

processes related to iron production, copper refining, silver recovery and cupellation, thus providing information about the many metalworking activities that at some point were performed in the area – most likely in connection to the refurbishment carried out by the Dominicans – and the technological knowhow of the artisans, who worked for the monastery.

The high amount of slags related to iron smelting is of special interest for two reasons. Firstly, because the recovery of evidence for this process in an urban context is extremely rare; and secondly, because the slags seemingly belong both to the direct and indirect smelting method. The production of iron by the indirect method is related to the invention of the blast furnace. In Europe, the earliest archaeological evidence of this type of structure dates between the 11th and the 13th century. Early blast furnaces and related metalworking debris were found in Lapphyttan (Sweden – Bindler, et al., 2011), in Schwabische Alb and Marckische Sauerland / Bergisches Land (Germany), in Dürstel (Switzerland – Jockenhövel and Willms, 1997) and in Ponte di Val Gabbia (Italy, located in the Lombard Alps, near Bergamo and Brescia – Cucini Tizzoni and Tizzoni, 2006). The last is an archaic double truncated square pyramid blast furnace dated by C14 between 1030 and 1270 AD. Another blast furnace, technologically more advanced than the previous one, connected to a large forge, have been found in Valle delle Forme (Val Grigna, province of Brescia), dated by C14 between 14th and 15th century (Cucini Tizzoni, 2008; Di Martino, et al., 2015).

Written sources, dated to 13th century, provide documentary evidence of permanent installations with furnaces, accommodation for workers, aqueducts and ancillary structures in Val Brembana. Other documents mention companies trading "ferrum coctum" ("cooked iron") and "ferrum crudum" ("raw iron"), at the same time. Both terms probably allude to indirect iron smelting: the pig iron, "ferrum crudum", coming out from blast furnace, needed a second melting in the reverberatory furnace/forge for conversion into iron or steel,"ferrum coctum" (Cucini Tizzoni 1994; 2006).

According to written sources, from the 12th century artisans from Bergamo and Brescia started to move to the Duchy of Milan (to which Pavia belonged), Tuscany, Veneto, Piedmont, and, during the 13th century, as far as the Kingdom of the two Sicilies, where they founded forge companies (Cucini Tizzoni and Tizzoni, 1993, p.82). From the second half of the 15th - early 16th century, migration reached international scale and their knowhow became widely popular all over Europe.

The rebuilding of the church of San Tommaso and the major refurbishment of the monastery, commissioned by Dominican friars and carried out between early 14th century and late 15th century, is contemporary to the first immigration of these highly specialized smiths from the Lombard Alps. Hence, it is possible to suggest that this workforce was employed in the building works in this site.

The blast furnace was not located inside the convent, since no trace of permanent structures have been documented during archaeological excavations, so how have the remains come to be found in the convent?

The dump content is very heterogeneous: other debris are related to the working and recycling of different base metals such as bronze, and to the recovery of silver: they are probably connected to the fabrication of objects to be used in the new church, the monastery and the *studium*. Production processes could well have taken place within the same yard. Whereas, iron smelting should be carried out elsewhere, in a place more suitable for heavy metallurgical activities. In fact, the monastery of San Tommaso is located inside the city walls near the civilian homes. But, if this is the case, what is the purpose of bringing the metallurgical debris to the monastery?

Many questions are still unanswered, and we hope to provide those answers in the second cycle of archaeometallurgy lectures to be given at the University of Sassari in the academic year 2017/2018.

However, so far we did reach at least one answer: considerable learning was achieved by academics and students in this process. There is still room for improvement, of course, but the experience was utterly enriching for all.

Notes

1 Multi-disciplinary Design and Education in the UK. Report and recommendations from the Multi-disciplinary Design Network. Design Council 2010

2 The first mention of the church is in a diploma of the bishop Arnolfo dating 889: this document records that the church is built on the ruins of older structures (Lanzani, 1989, p.20).

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Cover Images

1. Detail of a selection of finds from Třísov, an Iron Age *oppidum* in the Czech Republic. Metal objects such as these have been subjected to geochemical analysis, and conclusions regarding the metal supply at this settlement are presented by Danielisová, et al. Photo: A. Danielisová.

2. Detail of an elaborately decorated multi-ribbed dagger from a Middle Bronze Age II burial at Rishon le-Zion, Israel. This and other examples of MBA II daggers from burials from this site have been analyzed non-destructively to discuss the interrelationship of form and alloy and to gain information about technology and the supply of raw materials. See contribution by Kan-Cipor-Meron, et al. Photo courtesy of the Israeli Antiquity Authority.

3. Sampling of numerous Roman lead ingots has been carried out during the Corpus of Roman Lead Ingots (CRLI)-project. The present work discusses the analysis and historical context surrounding a special ingot with the inscription *metallo Messallini*. The contribution of Rothenhöfer, Bode and Hanel shows how the convergence of natural science, ancient history and archaeology can create a new and deeper understanding of past events. Photo: Rothenhöfer.

4. A cluttered office desk is commonplace in many professions. Archaeometallurgy is no exception. Writing and desk-based research belong to the daily life of archaeometallurgists, regardless of background, scientific training or career stage. The article of Sabatini and Mödlinger presents and discusses the results of an anonymous survey among archaeometallurgists that explores many aspects of this scientifically and socially diverse field. Photo: Mödlinger.

metallum, i, n:
Mine (often pl.)
Metal, also stone, mineral

μεταλλον, το:
Mine, shaft, gallery;
esp. a) Mine (usually pl.)
b) Quarry

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