

The Comacchio Glass Workshop

A Late Seventh-Century Urban Production Site of the North Adriatic

ABSTRACT This article is an in-depth review of the production structures found in Comacchio, dating to the middle of the seventh century AD, and the glass-ware, contextualizing both in the early medieval glass production processes. The final part of the article reflects on the role of Comacchio workshops in the Po Valley trading system and on the importance of these workshops for further developments in medieval glass production. For a general framework on the research project and on the excavation, see the article by Sauro Gelichi (in this volume).

KEYWORDS Early Middle Ages; goblets; lamps; production; trade; Po Valley

Introduction

This paper is a summary of the research on the glass materials and the glass-furnace excavated in Comacchio (Gelichi in this volume, Fig. 7.1) and dated to the mid-seventh century AD. The study of the evidence from the Comacchio excavation and the publication of the results finished around 2018 (Ferri 2021a; 2021b). However, reflections on what the Comacchio workshop might represent in the Italian and European early medieval period did not cease as the results were published. Therefore, this article is written with two points in mind:¹ firstly, to gather the ideas that have emerged from these thoughts and the numerous discussions I had with colleagues in the last year. The piece sets out to contextualize the

site and the finds within the early medieval glass-production panorama. Secondly, to respond to the need to present a succinct and informative synthesis for English readers.

The Comacchio glass workshop, dating to the mid-seventh century, was built in an area previously occupied by residential structures. In the area in front of the present Comacchio cathedral, the remains of a glass-furnace were brought to light. Only a part of the workshop (about one third) has been excavated. However, it is possible to propose a reconstruction by assessing the evidence (structures, holes, artefacts/objects) as a whole: some hypotheses on the construction and operating methods have been suggested on the basis of comparisons available in the scholarly literature.

In order to offer an overall interpretation of the topography of the site and to understand the specific use reserved for each area and the *chaîne opératoire* that characterized the entire workshop, interpretative phase plans were drawn up. These are based on the material traces found, including the remains of the iron and metal-alloy production structure located in the adjacent sector. The reconstructions are based mainly on a comparison with the traces of other excavated workshops and on the use of space and needs that emerged during experimental archaeological reconstructions (Taylor and Hill 2008).² These hypotheses do not explain every single trace and item recovered, but, when taken as a whole, they provide an understanding of the spatial arrangement and room for movement needed in a late antique glass workshop.

¹ This article is an English summary and discussion that include parts from earlier publications: Ferri 2021a; 2021b.

² Also see the online photographic material on 'Roman Glassmakers': <<http://www.theglassmakers.co.uk/archiveromanglassmakers/furnace1.htm>> [accessed 1 January 2022].

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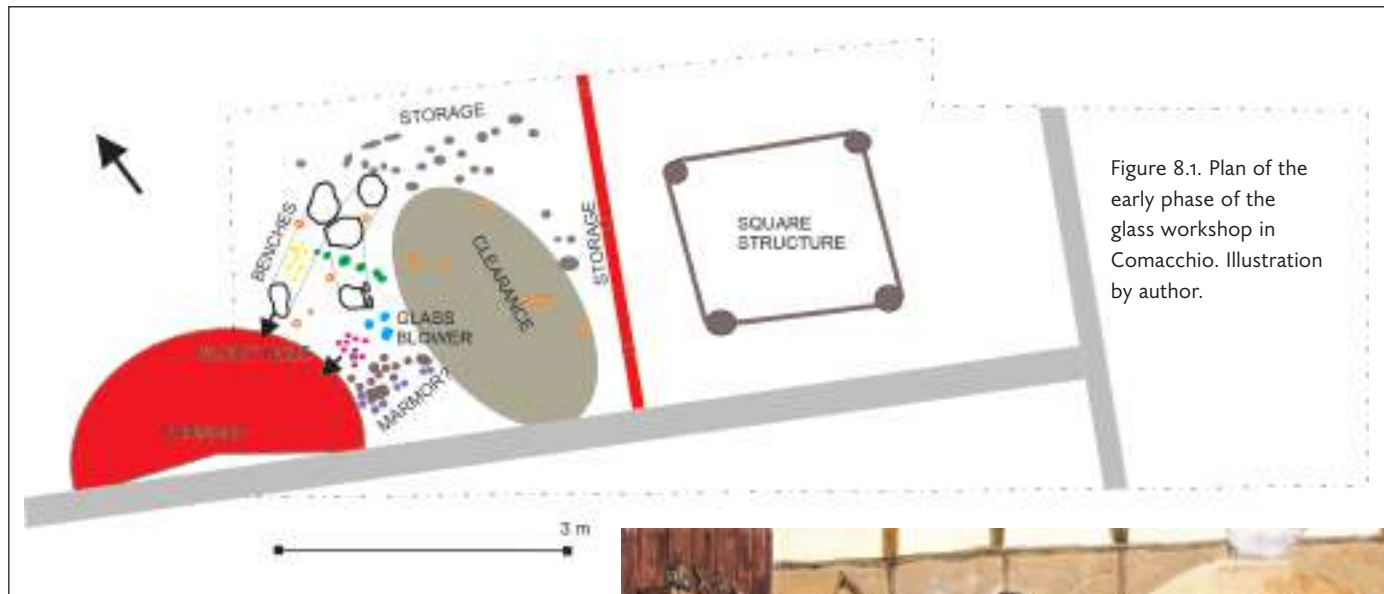


Figure 8.1. Plan of the early phase of the glass workshop in Comacchio. Illustration by author.

The Glass-Kiln

As said, only one third of the glass workshop has been excavated: it is possible to work out that the dimensions of the furnace were c. 2.4 m (southern side) by c. 1.2 m (this measurement is drawn from the hypothetical radius of the semicircle that the furnace occupies). The building materials used were not specifically sourced. This choice is unlike the one made for the tools and raw materials used, such as the containers for melting the glass, for which melting pots made of soap-stone imported from the Alps were specifically chosen and used. Bricks were used for the construction of the northern, semicircular furnace wall; in the southern part, however, the structure rested directly on the perimeter of the building, of which only the robbing trench remains, making it now impossible to speculate on the construction materials used.

The interior of the kiln (i.e., the burning chamber) must have been partially underground and sloping towards the centre of the structure itself. The bottom of the structure was therefore dug down some 10–15 cm below the floor of the workshop. A brick structure originally served as a support shelf for the crucibles; it probably collapsed during dismantling, and only a small portion remains in the south-eastern corner. It had the appearance of a horseshoe-shaped bench set against the side of the structure itself, and whose top must have been roughly level with the outer floor of the kiln (Taylor and Hill 2008;

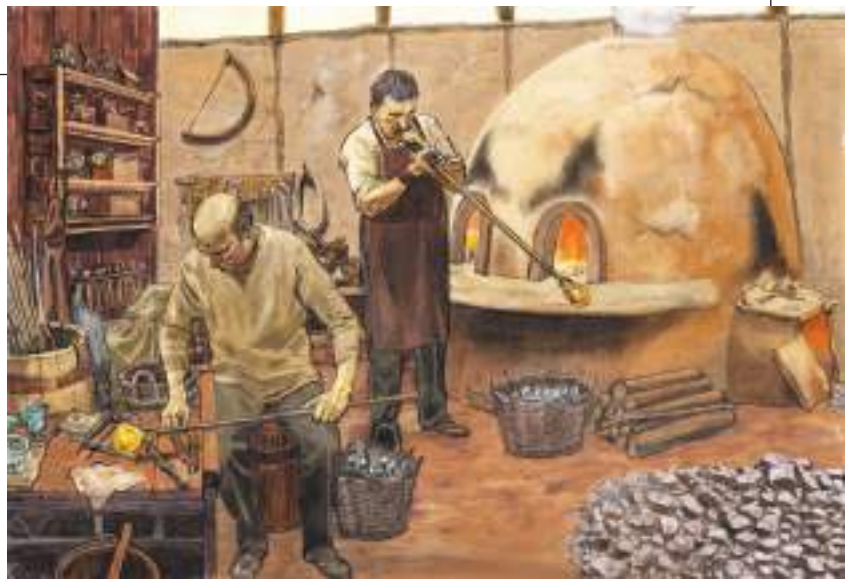


Figure 8.2. Reconstruction of the glass workshop in the earliest period. Illustration by Francesca Zamborlini.

Castillo, Palazón, and Thirirot 2004, 453). Below, in the burning-chamber pit, a rich layer of charcoal was preserved, while the shelf supporting the crucibles was at least partly covered by ash.

Since only the lower part of the kiln has been preserved, it is not possible to deduce its overall height. The access channel to the burning chamber was perhaps sited beyond the excavation limit, and therefore it is not possible to speculate on its shape.

The kiln was located inside a covered space: although only the southern perimeter has been identified, it is possible to assume that the sidewalls of the building were only partly built up, enough to protect the kiln from inclement weather and the winds and, at the same time, open sufficiently to allow the fumes to escape.

The Organization of the Workshop

In the area surrounding the structure, on the beaten clay that served as a walking surface, a large number of circular holes were visible, which were differentiated by size, shape, and position. Taking these three characteristics into account, although it seems difficult to trace the original function of each of them, it is possible to make some overall hypotheses.

The workshop was in use for long enough to have experienced some renovations.

The Earliest Period

With regard to the earliest phase of use, two groups of very small holes can be distinguished. They are spaced well apart from each other, and they arguably constitute the traces of the supporting devices for instruments such as blowpipes and pontils (Fig. 8.1, in pink and yellow). These holes constitute the key to the interpretation of the remaining traces. Both of these two groups of holes are accompanied by larger and more variously shaped holes that could represent the marks left by functional furniture for craft activities, such as benches or supports of blowpipes or for the laying of the *marmor* — the flat working table on which softened glass is rolled, when attached to a blowpipe or pontil, in order to smooth it (Fig. 8.1, in black and green, brown and purple). On the basis of the traces left on the ground surface, it seems that the presence of two different workplaces can be described quite clearly. They are set apart at a distance of 90/100 cm, a sufficient distance to allow enough ease of movement for two workmen engaged in the finishing of different objects, or working side by side in the application of decorations and accessory parts of a single vessel. If the workplaces were located to the north-east, it is again likely that the access to the burning chamber and the fuel-loading area were located in the area to the north-west, and not excavated.

All the holes identified were located in a buffer zone of a maximum width of 1.5 m around the structure of the kiln. To the east of them, there is an area where no traces of holes exist: this must have been a transit space, a corridor that linked different workplaces and the other activities that occurred in the immediate vicinity of the kiln itself.

In this older phase, the room to the east was subdivided by a wooden partition, beyond which there was a quadrangular structure that does not seem to have any relation to the furnace or the glass-making process. The presence of a continuous partition between the glass-processing area and the structure reinforces the hypothesis that the two structures are not related (Fig. 8.2).

Reorganization of the Workshop

Results of the enquiries into the durability of the structures made through experimental archaeology and drawn from ethnographic evidence (Paynter 2008; Gasparetto 1967) suggest that in a short time, perhaps within the time span of a single season, the kiln will have needed some restoration. On one such occasion in the workshop in Comacchio, the working area was reorganized.

Two subrectangular pits were opened to the north of the kiln, arranged at right angles to each other, probably for the storage of charcoal for loading the kiln and of exhausted ash, as the remaining fills suggest (Fig. 8.3, in grey). The positions occupied by the craftsmen blowing the glass seem to have shifted slightly, perhaps in relation to the new positioning of these pits. However, there are no indications that the number of workplaces was changed. However, the wooden partition was demolished, and the eastern part of the workshop was now devoted to metalworking facilities. This arguably led to a reduction in the space available to the glass-workers.

In the new set-up, the metallurgical zone and the glass workshop were located in the same large room/space. The passageway to the east of the kiln of the previous phase was maintained: a free area of about 1 m in width remains between the glass-making area and the serving structures of the forge. We have to assume, then, that the ancillary structures for the forge did not require the presence of a permanent worker in that corridor. There would not be enough space left for two craftsmen to carry out their work simultaneously (Fig. 8.4).

The presence near the northern limit of the excavation of a small ditch and some holes with a clear correlation with each other (Fig. 8.3, traces indicated in blue (a gully), pink, and light green) opens up the possibility of a second interpretation, based on comparisons with modern comparable structures. These could be the traces of a rudimentary water-powered air compressor necessary to guarantee the supply of sufficient air to make the fire burn hot enough. The use of this system is commonly dated to the modern period (Fig. 8.5); however, this technology has also been recognized in the metalworking area of a Roman rustic villa at Biberist-Spitalhof in Switzerland (Pleiner 2006, 159; Schuzany 1994). The arrangement works by allowing water to fall from an elevated tank and to collect under pressure in a conduit. When the water at speed debouches into a closed barrel, it forces a blast of air into the fire. It would thus be a system designed to replace the function of a bellows. In the case of Comacchio we have evidence of a channel for the water to flow down

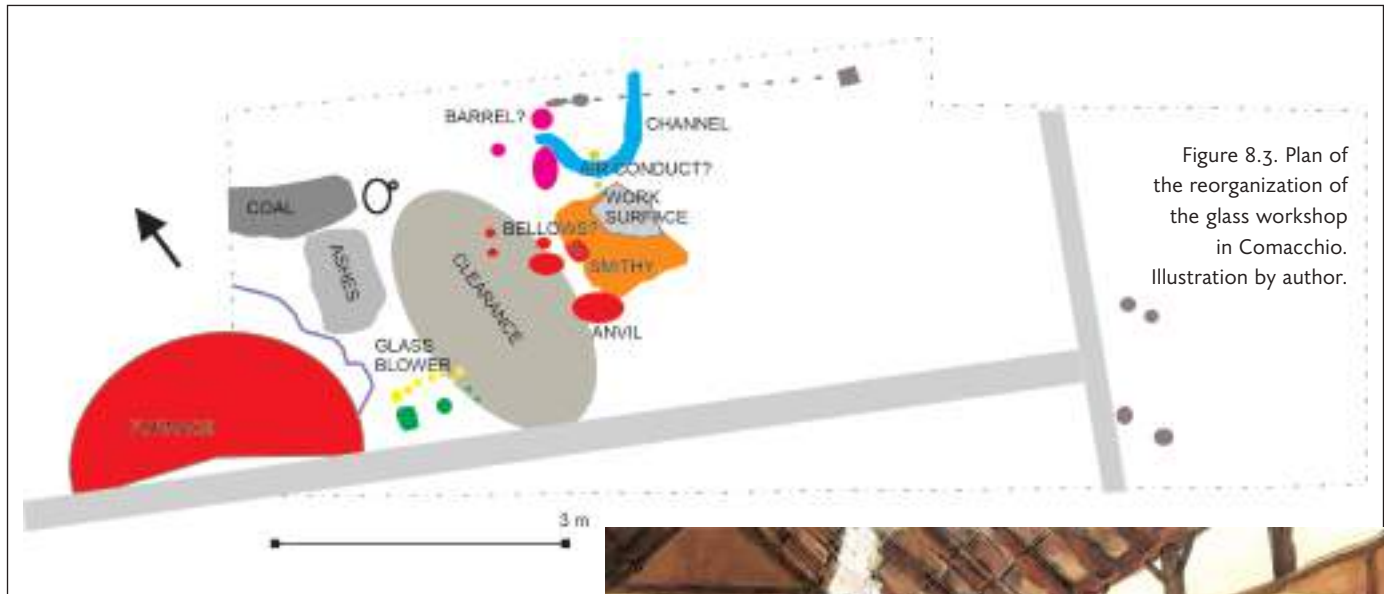


Figure 8.3. Plan of the reorganization of the glass workshop in Comacchio. Illustration by author.

from above (Fig. 8.3, in blue), post-holes which supported the structure/barrel in which the water was dropped (Fig. 8.3, in pink), and post-holes which supported the device conducting the air (Fig. 8.3, in light green) towards the forge-fire.

If this interpretation is correct, the traces located immediately to the west of the forge-fire should not be interpreted as the remains of a bellows, but perhaps as structures bounding the forge itself, or even as the remains of wooden furniture and the support for the anvil (unlike the reconstruction in Figure 8.4).

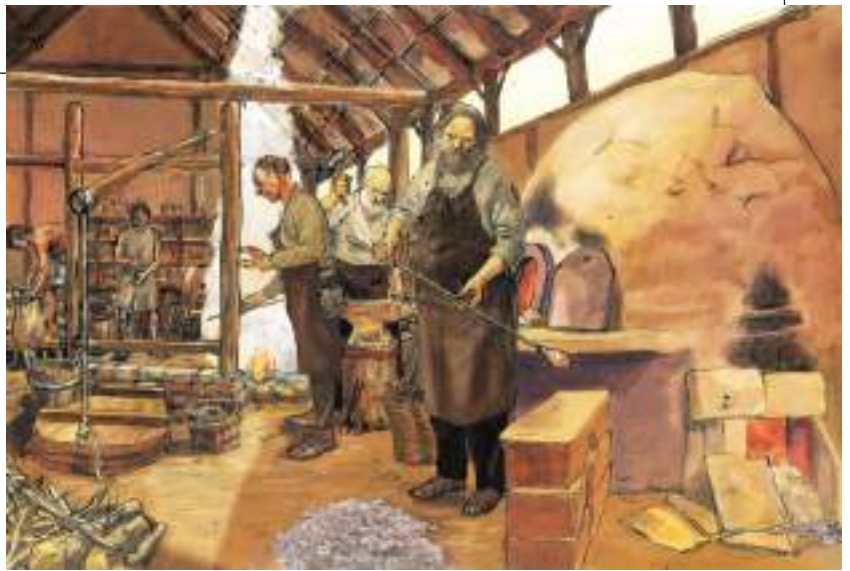


Figure 8.4. Reconstruction of the glass workshop in the middle period. Illustration by Francesca Zamborlini.

Abandonment of the Glass-Furnace

In the next phase, the entire room underwent new rearrangements. First, the glass-furnace cannot have still been in use, since no waste was found in this phase. Some of the structures remained, probably for a short period of only a few years. This phase is strongly characterized by the presence of a blacksmith, who takes over some of the space previously reserved for the movement of the glass-workers.

The main forge-fire was moved towards the east, to a different position. The presence of a new partition, even though it was of limited height and only there to protect the bellows, forced the workstations to be revised (Fig. 8.6). If previously the blacksmith was believed to have been positioned east of the forge-fire, with this arrangement of a new partition, the blacksmith would necessarily have to position

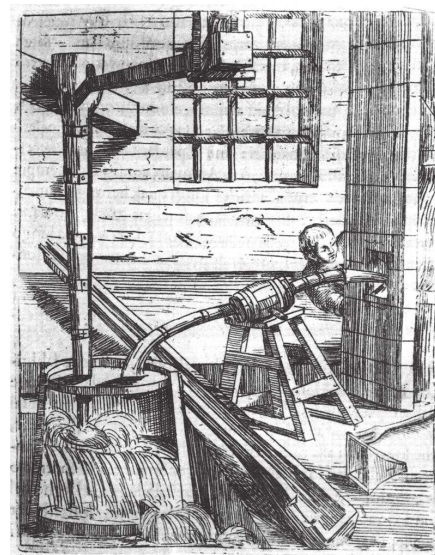


Figure 8.5. Water-powered air compressor. A. Della Fratta, Bologna 1678, source: Wikimedia Commons.

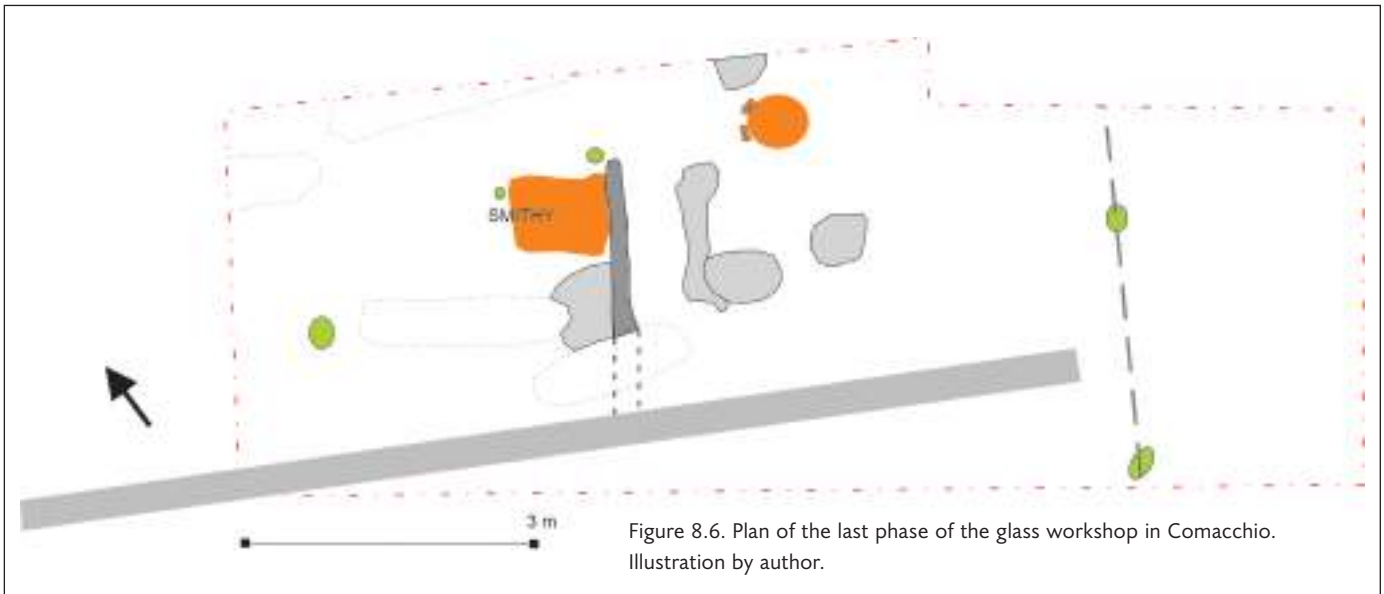


Figure 8.6. Plan of the last phase of the glass workshop in Comacchio. Illustration by author.

Table 8.1. Quantities of identifiable objects, non-identified objects, and waste fragments.

| | | |
|-----------------------------------|-----|-------|
| Identifiable objects, fragments | 531 | 27.3% |
| Non-identified objects, fragments | 901 | 46.4% |
| Waste fragments | 510 | 26.3% |

himself to the west. The presumed water-powered air compressor is not rebuilt. But the boundary of the workshop to the east remains unaltered: two holes mark the edge of a canopy where there was previously a partition.

Comacchio's workshop highlights a gradual increase in the importance of metalworking at the expense of glass-working, but we cannot rule out the possibility of the glass workshop having simply been relocated elsewhere. The excavated area is, at the moment, very limited, and this only allows for speculation. However, if we are correct in sensing a growth in the importance of metalworking, we should also infer a change in economic direction.

At the end of the seventh and the beginning of the eighth centuries, the entire area was affected by wholesale dismantling and levelling work, which marks the end of all craft activities previously set up in the area. The remains of the working structures are flattened to allow for the preparation of a burial area.

Although the workshop can be seen to have undergone some refurbishments, there are no *ex novo* reconstructions. It thus does not seem to have had a long life. The whole sequence of the construction of the glass-furnace, its use with some restorations, and its decommissioning, at first alongside and then being replaced by metallurgical activities, culminat-

Table 8.2. Quantities of ornamental objects, tesserae and windowpanes, glasses and goblets, bottles, and lamps (minimum number of objects).

| | | |
|--------------------------|-----|-------|
| Ornamental objects | 1 | 0.4% |
| Tesserae and windowpanes | 74 | 27.5% |
| Glasses and goblets | 156 | 58% |
| Bottles | 21 | 7.8% |
| Lamps | 17 | 6.3% |

ing in its final abandonment and removal has to be packed into a short period of time, just a few years, between the middle of the seventh and the beginning of the eighth centuries.

Comacchio Glass-Ware Production

A total of 1942 glass fragments were collected during the excavation. The finished glass objects found are numerous (altogether there are 531 fragments attributable to 269 individual objects). They are for the most part goblets and drinking-glasses (even though it must be pointed out that — for the most ancient phases up to the tenth century — the discovery of no cone-shaped bases could suggest that the rims should only to be attributed to goblets), and a few lamps and bottles (Tables 8.1 and 8.2). With glass vessels, it is not always easy to determine which were the products of the glass workshop and which were collected for recycling. It is now accepted that glass recycling was a very common practice. Based on analytical data from previous research, 50 per cent of glass objects have at least one marker indicating recycling, but since recycling within the same compositional group is difficult to recognize, it is possible that vir-

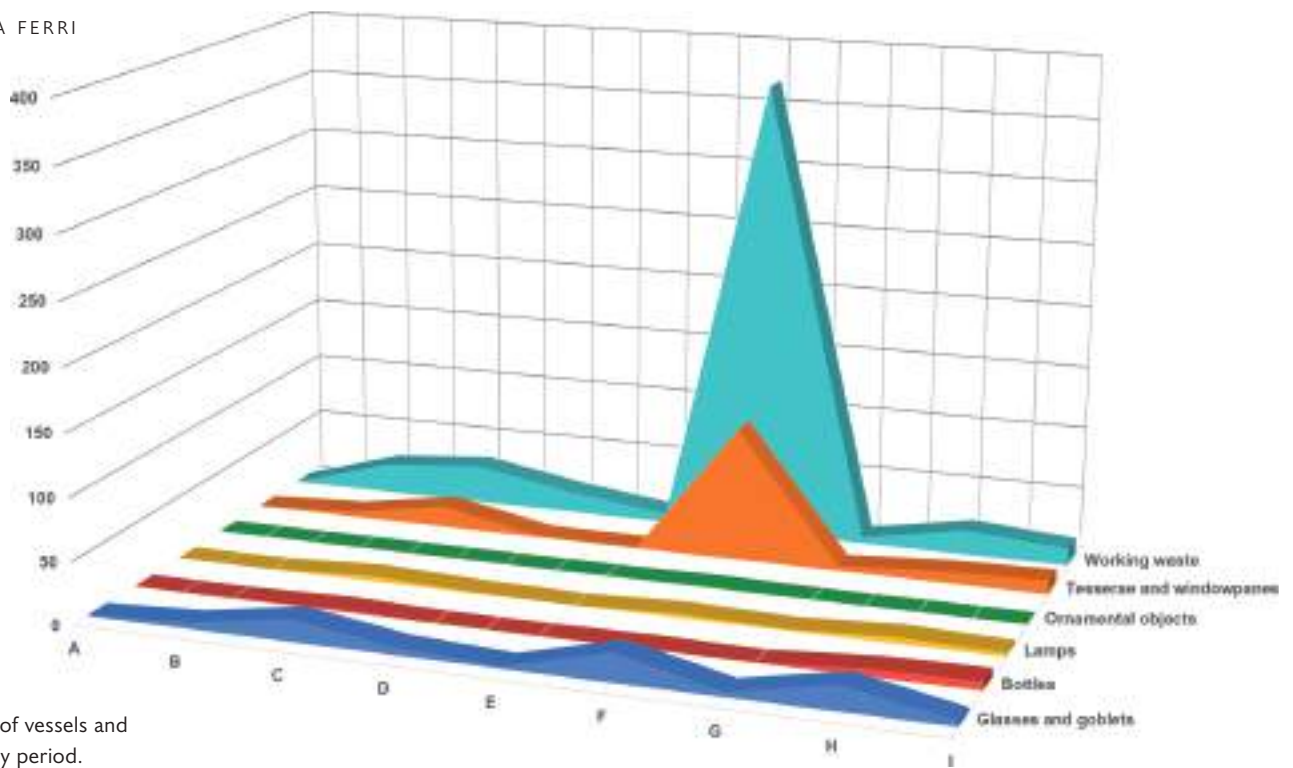


Table 8.3. Quantities of vessels and glass objects found by period.

| | | Glasses and goblets | Bottles | Lamps | Ornamental objects | Tesserae and windowpanes | Working waste |
|----------|--|---------------------|---------|-------|--------------------|--------------------------|---------------|
| A | Before the glass workshop (second half of the sixth century) | 1 | 0 | 0 | 0 | 0 | 0 |
| B | Glass workshop first phase (middle of the seventh century) | 5 | 0 | 0 | 0 | 4 | 24 |
| C | Glass workshop second phase (second half of the seventh century) | 18 | 2 | 4 | 0 | 17 | 31 |
| D | Glass workshop defunctionalization (end of the seventh century) | 6 | 0 | 1 | 0 | 1 | 17 |
| E | Glass workshop abandonment (beginning of the eighth century) | 2 | 0 | 0 | 0 | 1 | 7 |
| F | Graveyard (eighth–eleventh centuries) | 23 | 1 | 3 | 1 | 107 | 369 |
| G | Episcopal building (twelfth–fourteenth centuries) | 4 | 0 | 1 | 0 | 4 | 5 |
| H | Building (end of the fourteenth–middle of the sixteenth centuries) | 20 | 6 | 5 | 0 | 9 | 20 |
| I | Modern-time graveyard (second half of the sixteenth–seventeenth centuries) | 4 | 7 | 3 | 0 | 11 | 14 |

tually all ancient and medieval glass underwent at least one recycling process (Duckworth 2020). The finds of glass objects and working waste are distributed throughout the entire excavation sequence. But between the eighth and eleventh centuries, the area was used as a cemetery: the excavation of the tombs affected the deposits with the furnace, bringing to the surface much material that actually belongs to earlier phases (Table 8.3).

The most numerous finds are goblets and lamps (Fig. 8.7), recovered along with some bottles and tesserae. Objects of an elite nature in different mate-

rials occur too, testified to by moulds for the production of glass cameos and for bronze letters (Fig. 8.8) (Gagetti 2021; Mitchell 2021).

We can argue that small goblets with a flattened disc base between 3.6 and 4 cm in diameter are the main output of the late seventh-century workshop. This deduction comes from the nature of the working waste: four rims and a goblet disc base show traces of tweezers and shears. Their presence is not plentiful because defective objects could easily be remelted, but it is significant that the only failed vessels found are goblets. Other working

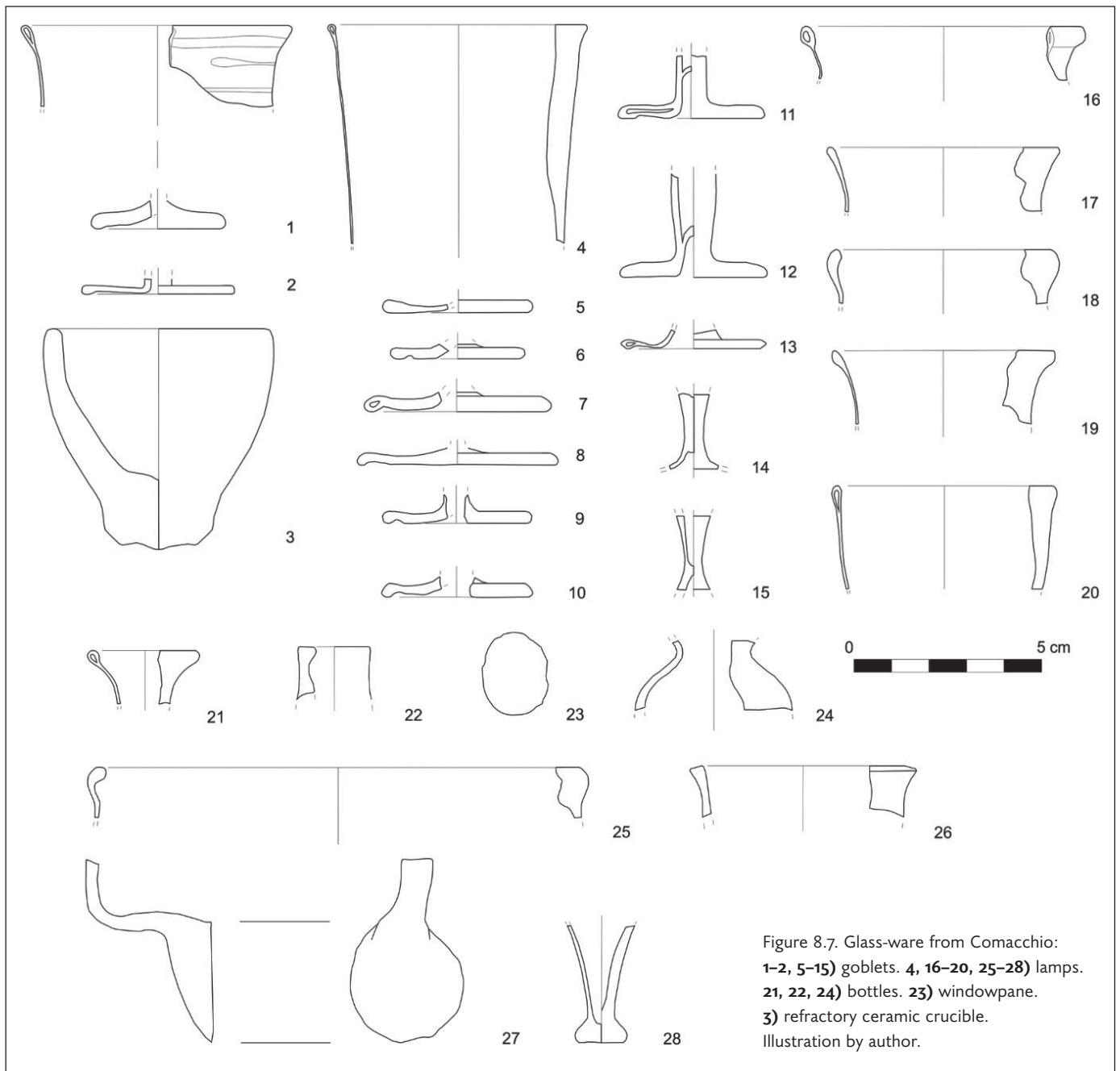


Figure 8.8. A matrix for cameos, a mould for a letter from Comacchio, and a *capsella* (a container used as a repository for relics) from Cividale del Friuli (Chiesa di Santa Maria Assunta, Museo Cristiano e Tesoro del duomo di Cividale, IG00099147) on display in Bologna in December 2018. On the slope of a short side of the lid of the *capsella* there is a cameo made with a very similar matrix, but not the same, as the one from Comacchio (on these cameos, see Galletti 2021). Photo by author.

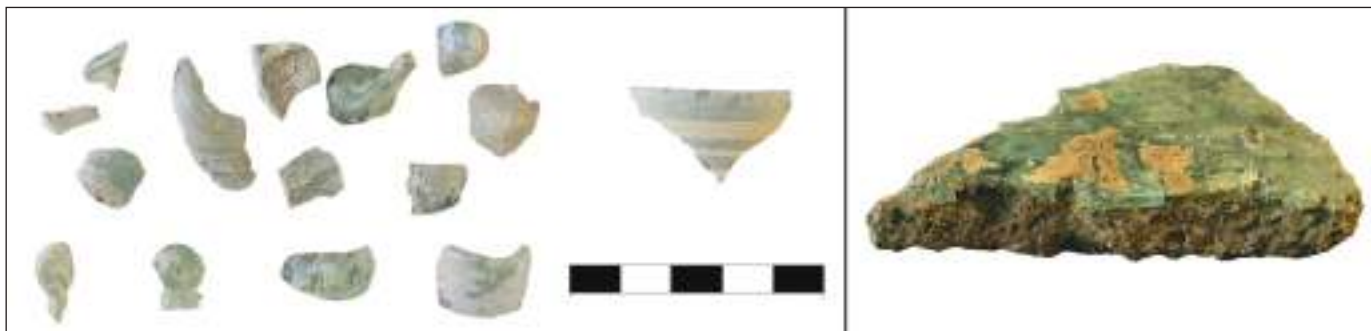


Figure 8.9. Glass waste from Comacchio. On the left: some drops, filaments, moils, and small blocks. In the centre: a glass rim with marbled decoration. On the right: a soap-stone crucible with a layer of glass on it. Photo by author.

wastes³ include drops, drips and filaments, skins, small blocks, moils (remains of the detachment of the vessel from the blowpipe), and cut-outs produced during the finishing of the objects; none are attributable to a specific form. Soap-stone and refractory ceramic crucibles were also retrieved (Fig. 8.9 and Table 8.4).

In the second phase of production (when the altered forge was also in greater use) goblets with a big bowl and everted rim, embellished with white marbled decorations were also produced. This can be deduced now only from the analysis of the finished objects: the number of goblets totals eighteen specimens (Table 8.3). There is no proof of defective goblets with white marbled decoration. When the workshop was no longer active, the glass-ware still being found shows an increase in the diameter of the bases of the goblets, which is now around 5 cm. It is still to be determined if these goblets are products made in Comacchio (in a new workshop that we have not been able to locate), or if they are products from somewhere else brought into the village.

These data certify, therefore, the predominance of the goblets among glass vessels in the seventh century, marking, on the one hand, the disappearance of older forms, such as the typical beaker with slightly concave or flat bottom of the fourth and fifth centuries (Uboldi 2007) and highlighting, on the other hand, the capability of the goblet to replace many other forms and for being used to serve many functions.

The very few fragments of bottles are almost certainly pieces intended for recycling, because of their intense blue colour that is different from the glass-ware identified as products of the workshop, all of them being green. In fact, a careful selection of materials to be recycled was made on the basis of the characteristics of the new product to be obtained.

Table 8.4. Quantities and typology of glass-working waste.

| | | |
|-------------------------------------|------------|-------|
| Drips, filaments | 179 | 35.1% |
| Skins | 52 | 10.2% |
| Small blocks | 81 | 15.9% |
| Moils | 16 | 3.1% |
| Cut-outs | 142 | 27.8% |
| Failed vessels | 7 | 1.4% |
| Soap-stone crucibles | 31 | 6.1% |
| Refractory ceramic crucibles | 2 | 0.4% |
| | 510 | |

There is a positive correlation between small non-blown and intensely coloured objects and a high incidence of recycling: in this way, the addition of colourants or objects to be recycled in solid colours would have made the mixing less evident. In addition, structural weaknesses due to recycling are also less frequent in objects heated and shaped at low temperatures rather than blown (Duckworth 2020, 332–33). This procedure is the specific case in Comacchio, where we know glass cameos were also produced. For lamps, the situation is less clear. Some have been found in the eastern sector of the complex, furthest away from the workshop structure and where, a few decades later, the cathedral would be built. The lack of waste certainly attributed to lamps makes it possible that these vessels were not produced in Comacchio. They potentially had a very specific and limited use in religious contexts such as churches and cemeteries, while the goblets could also have served for lighting in domestic residences.

In their shapes as well as from a chromatic point of view, Comacchio glass reflects the production of other contemporary coastal or lagoon centres such as Torcello (Leciejewicz, Tabaczynska, and Tabaczynski 1977; Ferri 2006; Marcante 2014), Classe (Augenti, Cirelli, and Marino 2009; Cirelli and Tontini 2010), and Grado (Marcante 2007). These are places characterized by the reliable (Torcello and Classe) or probable (Grado) presence of a glass workshop (see below) and the presence of harbours or, at least, of

³ Interpreted on the basis of Fenzi and others 2012.

warehouses. Grado and Torcello, moreover, share the same productive specialization as Comacchio: both of them produced almost exclusively goblets.

As mentioned, the goblets constitute an almost ubiquitous presence in the Italian Early Middle Ages. With their appearance, a most evident change in the working of glass takes place: the functional forms are reduced in the late antique period (only goblets and lamps, as bottles vanish from the scene). This change in the range of available products can be correlated with the changes to be observed in the glassware furnaces that are larger and better planned.

Other Early Medieval Workshops

The Comacchio workshop flourished in a crucial period in the history of glass production. At the end of the seventh to the beginning of the eighth centuries, several developments in this industry can be listed: these involved the production processes, as the raw materials for the primary recipes themselves were altered (Phelps and others 2016), but also the structure of the secondary workshops where the semifinished products were transformed into objects different in character.

It is only in recent years that the number of stratigraphical excavations and thus a reliable accuracy of dating has increased dramatically (Sagui and Lepri 2015). A fairly clear distinction is beginning to emerge between glass production before and after the seventh century. A second demarcation point can be placed roughly around AD 900 to 1000. Though this latter demarcation point is perceptible, it still needs to be clarified in chronological, quantitative, and qualitative terms.

Glass Recipes

In this context of enormous changes in glass production, the Comacchio workshop only partly used 'fresh' glass of the Apollonia type (i.e., semifinished products from Levantine coast sites — present-day Israel — brought to Comacchio), but mostly the workshop relied on 'recycled' glass which contained mixtures from the Egyptian (HIMT) and Levantine areas (Bertini, Henderson, and Chenery 2020). Only one glass sample using a mixture containing plant ash as a flux belongs to the furnace's lifetime phase, out of a total of approximately one hundred samples processed. The data do not seem sufficient for postulating an early use of this plant-ash recipe in northern Italy as a result of a hypothetical direct commercial relation with northern Syria, where the first production areas of this new glass type are located.

According to a recent study on early Islamic glass from Palestine (Phelps and others 2016), a change in the location and in the production organization of primary glass workshops occurred in the late seventh and early eighth centuries. A relatively abrupt compositional change marks the end of Apollonia-type glass and the simultaneous establishment of the furnaces at Bet Eli'ezer. Glass of Egyptian origins becomes prevalent again in the eighth century, after a previous floruit in the fifth to sixth centuries AD (Phelps and others 2016, 65, fig. 9). As the authors of the study point out, there is likely to be a slight vagueness in the chronological phasing, influenced by sampling strategy and site context. This imperfect chronological alignment may also be due to the fact that the introduction of a new recipe is visible from the archaeometric point of view only if a large-scale analysis is undertaken. This means that this new recipe can be identified only when it has successfully become very widespread on the market, and when its dilution with older recipes becomes less pronounced (Duckworth 2020, 326–32). With all this in mind, it must be emphasized that this critical chronological span is precisely the one in which the Comacchio furnace flourished and vanished.

From the point of view of primary workshops, a centralization of the structures and control of production is observable, a gradual process of relocation close to the authority that managed the logistical and organizational aspects. This process is evident and reaches its peak in the transfer of the glass industry to Samarra, a newly founded industrial city, in correspondence with the caliph's move from Raqqa to Baghdad in AD 808 (Henderson 2013; but see also Phelps and others 2016).

Secondary Glass Workshops

As far as secondary workshops are concerned, for the Italian territory there is no general model applicable for the early medieval workshops, at least as far as size, shape, and constructional features are concerned.

Among the workshops dating from the fifth to the seventh centuries some aspects seem to constitute a sort of common denominator: they are located in urban areas that were previously built upon, but which lost the original functions they had in Roman times. In particular, they are located inside buildings already abandoned and then converted into something else, where the walls still partly stood. There are numerous examples of this: Crypta Balbi (fifth-century kiln) (Sagui 1993; 2000), Nora (Giannattasio 1996), Trento (Cavada and Endrizzi 1998), Classe (Augenti, Cirelli, and Marino 2009;

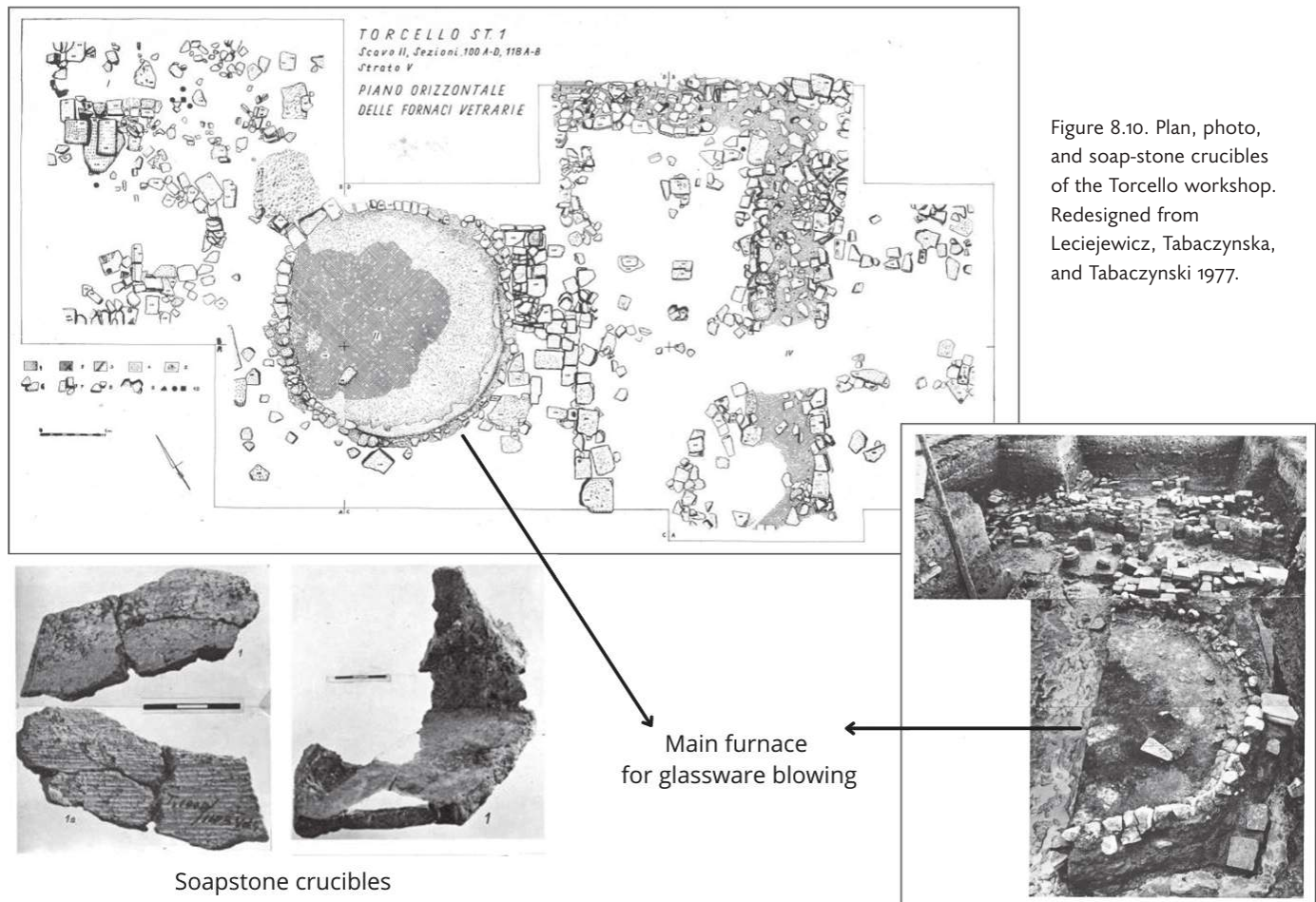


Figure 8.10. Plan, photo, and soap-stone crucibles of the Torcello workshop. Redesigned from Leciejewicz, Tabaczynska, and Tabaczynski 1977.

Cirelli and Tontini 2010), Aiano Torracchia di Chiusi (Cavaliere and others 2010; Cavaliere 2011; Cavaliere and Giunlia-Mair 2009; Deltenre and Orlandi 2016; Boschetti and others 2021), Spolverino Albarese (Sebastiani and others 2015). Moreover, there are discoveries of accumulations of waste in urban areas, which, though not directly associated with a kiln, likely indicate that a kiln was located not too far away, such as glass-working waste found near the area of the Capitolium in Verona (Roffia 2008, 514–15), or the case of the Basilica Hilariana, which became an imperial property in the fourth century, and was perhaps assigned to private individuals who set up several craft activities there (Pavolini and Palazzo 2013), and finally in the case of Aquileia, where windowpanes and mosaic tesserae were sought out and recovered for recycling (Boschetti, Mantovani, and Leonelli 2016).

In many cases, the location seems to be mainly influenced by the ability to recover building material for fashioning the structure of the workshop, without regard to its main intended function. Some cases, however, indicate a fondness for a location in bath buildings: the Sofiana workshop in Sicily, dat-

ing to the sixth century (Fiorilla and others 2018, 112); the Piazza della Signoria workshop in Florence, later than the middle of the fourth century but earlier than the seventh century (De Marinis 1991); the kiln of Santa Cristina di Caio (Buonconvento near Siena), dating to between the fourth and fifth centuries, where the spoliation and recycling of ancient materials is associated with both glass- and lead-working (Bertoldi and Valenti 2015).

The location within baths could also be connected with the primary function of the workshop: the easy recycling of glass windows and mosaic tesserae, with which the baths had been commonly equipped since the first century AD. In all these last examples, however, indications of different handicraft productions are demonstrable alongside that of glass, so it is likely that the generic presence of construction material suitable for pyrotechnological applications was also decisive when choosing the location of the workshops. Craftsmen themselves could be working a whole range of materials, because the crafts shared knowledge on pyrotechnics, and because many activities have to do with waste processing (Duckworth and Wilson 2020, 2).

The usually rather small size of the kiln (around 1 m in diameter) and the general lack of clear signs of restoration, except the case of a structure in Trento (Cavada and Endrizzi 1998), together with their location in semi-central areas of the town, all indicate that these were individual initiatives with little 'environmental impact', short term, and geared to local production. A glass-furnace could have had an average life limited to but one season, unless major maintenance was carried out (Gasparetto 1967; Taylor and Hill 2008). In such cases, the hypothesis of itinerant artisans working in secondary production, using pre-melted glass masses and cullet, and fuel collected locally, remains plausible. All the artisan needed, moving from one location to another, was his own know-how and possibly a limited number of semifinished products, to which he could add recycled glass.

The Comacchio workshop cannot be equated with those temporary structures used by itinerant artisans who employed mainly, if not only, cullet and addressed local buyers. Rather, Comacchio can be considered a complex set-up which, while continuing to use in part recycled glass, supplied a wider market. Thus it boasted a purpose-built workshop, using special equipment and instruments, sometimes not local, such as the soap-stone crucibles imported via the Po from the central Alpine area (Mini and others 2014).

A change in the production arrangements of primary workshops (from a monopoly of Apollonia-type glass to a concurrence from several sources) corresponds to a change in secondary production. In Late Antiquity, very large industrial workshops for the production of semifinished products lay at the base of a wider, secondary, and dislocated production system of a substantially local character. This production system had access to circumscribed structures and resources, and was probably run by individual craftsmen, aiming at a level of production closely linked to local demands. From the middle of the seventh century, at least according to the data from Comacchio, and in the centuries immediately following, this system was accompanied by new ways of proceeding.

The size of the production complex in Comacchio (as well as its location in a lagoon area, a pivotal point between sea and river navigation systems) makes it similar to the glass workshop discovered in the 1960s in Torcello (Fig. 8.10), attributed to the ninth century at the earliest (Leciejewicz, Tabaczynska, and Tabaczynski 1977; Leciejewicz 2002). In both cases, the kilns are quite large (2.5–3 m in diameter), newly planned, close to an ecclesiastical area in the case of Torcello (about 35 m from the cathedral complex), and exactly where the bishop's church would soon

be built in Comacchio. In Torcello, a production model based on the processing of semifinished products with the addition of recycled material was used (Verità, Renier, and Zecchin 2002), as seems also to be the case in Comacchio. In both places, cullet included mosaic tesserae (Ferri 2006), and soap-stone crucibles of Alpine origin were used for the process of remelting the glass mix.

Because of these specific characteristics Comacchio and Torcello can be considered as organized workshops, in which the glass production did not take place extemporaneously as enabled by the availability of local resources, as was the case in previous late antique examples. The two workshops in Comacchio and Torcello were ateliers that sought out and used specific materials, they were planned and conducted a structured production. We do not have clear information about Torcello, but the kiln of Comacchio was restored at least once, and the whole atelier, when the nearby forge is also taken into account, does not pursue a straightforward history. These circumstances, in my opinion, make it different from the previous glass ateliers, which apparently arise and disappear like mushrooms in the woods, leaving no trace.

Although the excavations covered limited areas in Comacchio and Torcello, in both cases indications of other types of craftsmanship were retrieved: in Comacchio, metals were crafted, but perhaps also bone and horn (Garavello 2021, 365); in Torcello, metal scraps and objects have been found in the layers associated with the life of the glass-furnaces (Leciejewicz, Tabaczynska, and Tabaczynski 1977, 59). In addition, from recent research in Torcello, near the cathedral, traces of processing horn and bone have emerged, but it is not clear to what date these finds belong (Seetah and Pluskowski 2014, 140).

The proximity of different manufacturing activities, each specialized in different products, is a recurring motif in all these workshops, no matter if they belong to the late antique or early medieval model. The close proximity of different craft activities had a practical aim: that of maximum exploitation of the production structures and of maximizing the yield through the materials used, including waste materials (see e.g. Peake and Freestone 2012; Duckworth and Wilson 2020). Moreover, it seems to be possible to affirm that the deeper we proceed into the Early Middle Ages, the tendency to accommodate several crafts in one area is accompanied by the addition of further logistic and commercial structures. The kiln of Classe is one of the earlier examples of a space in which the productive and commercial functions overlap. The workshop is dated between the mid-fifth and seventh centuries (Cirelli and Tontini 2010, 126–27).

A building with a complex plan, set on the walls of a suburban villa, was located within a quarter in which a road flanked by buildings, warehouses, and production kilns ran parallel to a canal (Augenti 2019). The district was located in the immediate vicinity of the complex of the basilica Petriana, the baptistery, and monasteries, whose construction dates from the second quarter of the fifth to the beginning of the sixth centuries (Bermond Montanari 1983, 26–27). Numerous waste products, remnants of half-melted glass, and a pulverized glass cake, ready to be used, were found. It is a structured complex, located near harbour docks and numerous crafts were practised there: immediately outside the same building was a lime-kiln and nearby metals, bone, and perhaps wood were processed.

Torcello and Comacchio share some of these characteristics with Classe. We can hypothesize the existence of proto-industrial complexes, meant as places where the working of raw materials and the making of different products were carried out, with an immediate opportunity for exchange and trade. In these ateliers, the trafficking of goods seems central, both that of raw materials and the distribution of finished products. At Comacchio, moreover, the work area was part of a context characterized by several set-ups, and it seems that items were destined for specific markets and destinations, while some areas served warehouses, port infrastructures, and production areas, almost as if they were planned at a general topographical level. In the area of Villaggio San Francesco, warehouses and port structures last longer: they date from a little later (eighth and ninth centuries AD).

Why a Glass Workshop in Comacchio?

The emergence of these new urban centres that enclose both a productive function and a redistributive one (such as Comacchio and Torcello: arguably to be thought of as emporia, places where supply is crucial, for geographical and political reasons, and places located so as to serve very different territories) replaces the fragmentation and low standardization accompanying a bazaar-style economic setting, where integration between the different agents (primary producers, secondary producers, buyers, consumers) is very low with a 'relative unpredictability of supply and demand' (Bang 2008, 4). This bottom-up model based primarily on individual interactions does not prevent the emergence of larger-scale distribution patterns.

The emporia of northern Italy represent a different economic model, one with a top-down organization and where the fragmented approach and operation of

individuals is reduced. We are unable to clarify exactly how the transition from one model to the other took place, but the need to replace the old Roman state system led to a change. The bottom-up system that arose between the fifth and seventh centuries in the vacuum left by the Roman imperial organization, morphed into a top-down system, visible from the second half of the seventh century onwards. The geographical position that guarantees a good supply and distribution triggers a consideration of how the products were then reallocated throughout the territory. First a boat is required, which from its design and size could carry large and bulky loads. Remains of a river barge from the fifth century AD of at least 22 m in length was recovered in the area of Santa Maria Padovetere in Comacchio: it presents a flat bottom without a keel and sides joined at 130° to the bottom strakes midships. It is made from a *Quercus sp.* (oak) and *Ulmus* (elm). Regarding the mode of propulsion of this boat, primary sources suggest the use of either oars or towing, which was the normal mode for barges along the Tiber in the middle of the sixth century AD (Beltrame and Costa 2016). A second type of vessel was the logboat (a hollowed-out half of a tree-trunk), used in the Po Valley from pre-Roman times to the Middle Ages. At least eighty logboats are listed in northern Italy. They are quite widespread: many in the Po River, but significant concentrations are near the Comacchio Valley and in the rivers around the Venetian Lagoon. Bigger logboats are between 10 and 16 m long (Lucchini 2020). These characteristics suggest that logboats were maybe used for less bulky cargoes than barges. It is therefore possible to hypothesize the arrival by sea on larger ships of products and raw materials that were then redistributed through the river routes inland. Accurate data on the actual distribution of products made in places like Comacchio and exchanged along the river routes and all hypotheses based on archaeometric analyses as to their degree of penetration into the Po Valley are completely unavailable at the moment.

The oldest phases of the excavation in the area of the Comacchio cathedral date to the sixth century, with the presence of a wooden building, followed by the establishment of production facilities, which in turn were obliterated by a cemetery probably belonging to the nearby cathedral church. The workshop was active in the second half of the seventh century. Liutprand's capitulary of AD 715 or 730, which regulates commercial traffic along the Po, mentions the *habitatores* of Comacchio led by presbyter Lupicino, a *magister militum*, and two *comites*; a diploma of AD 781 certifies the presence of a bishop representing the community; finally, in a *placitum* of AD 801, the Comacchio inhabitants themselves are

asked to identify their own representative in court (Gasparri 2015). The written sources do not help to define who led the community.

There had to be some form of management, whether by an individual or by community representatives. Comacchio testifies to the appearance of structured, large-scale workshops, where supply of non-local equipment and raw materials were ensured, perhaps benefiting from the general topography of the settlement that made it functional for production and sales.

The main products are goblets. These are the leading type-fossil of the Early Middle Ages, and the Comacchio evidence could suggest that they are to be associated with coastal settlements with emporia characteristics (and so ease of distribution), as at Comacchio and Torcello. Therefore, we have no certain information about who was in charge of the management of the workshop. A possible link between ecclesiastical structures and glass production can only be speculated upon. In the first phase of Comacchio's production this link is not at all certain; indeed, the lack of lamps for lighting among the kiln's products would lead one to think that the output was aimed at a secular market.

However, Torcello and perhaps also Grado seem to point explicitly in this ecclesiastical direction, with a direct involvement of the Church in the production and trade of glass products, at least judging from the topographical proximity of workshops and ruling churches. Grado is a less certain case: about fifty glass-waste pieces were recovered from an excavation in proximity of the bishop's church dedicated to Saint Eufemia. Certainly the blowing of glass objects (goblets and lamps) (Marcante 2007) took place in Grado in the surroundings of the cathedral around the seventh and eighth centuries AD, but probably not in the two furnaces excavated in room 1 (Lopreato 1988), which were perhaps intended for other crafts.

Church involvement recalls another Italian glass workshop: the collective in San Vincenzo al Volturno (Hodges, Leppard, and Mitchell 2011, 129–93). In this case the ecclesiastical link is certain: San Vincenzo dates to the ninth century, while Comacchio dates to the second half of the seventh century and the dating of the Torcello workshop remains doubtful, but lies within this time span. Ian Wood (2021) identifies in the Church the new agent that would carry out this function (also see Hodges in this volume). In the Early Middle Ages the Church became progressively richer, and in the seventh century a turning point was reached in which the Church's wealth changed from being made up primarily of movable items to immovable landed property (where the glass work-

shops would be located starting from the middle of the seventh century). This latter constituted a source of renewable wealth, something necessary to feed the growing needs of this institution and the people who relied on it. This model finds partial confirmation in the analysis conducted thus far on glass workshops of the northern Adriatic area. We do not have enough detailed chronological data, but perhaps we are dealing with broadly similar examples, the result of a cultural and geopolitical change in which the presence of the Church as an actor becomes more and more evident until we enter the ninth century, when this involvement is self-evident.

All in all, Comacchio in the second half of the seventh century testifies to a glass-ware production model different from the past, similar to the case of Torcello most likely in the ninth century. This hypothesis is drawn from the fact that both of them are new settlements in the upper Adriatic Sea with a fundamental role in the reorganization of local and Mediterranean-scale trade (Gelichi, Negrelli, and Grandi 2021). They emerge in border territory, both from an environmental point of view (on the edge between the land and the sea) and from a political point of view (between the 'Byzantine' sphere of influence and the 'Lombard/Carolingian' western one): a perfect example of a permeable frontier characterized by human and commercial interpenetration (Gelichi 2018). Both used the same raw materials and produced goblets. Other instances (Grado, and maybe Classe) appear to be comparable, although the data is less complete.

What happens next? Is Comacchio in some way connected with the Murano glass production through the mediation of Torcello? Technical and artistic interactions between Venetian glass-makers and those of the Byzantine and Islamic worlds have been assessed, and it has been suggested that the origins of the Venetian glass tradition lay in the contact that Venice had with the Islamic world, mainly from worker migration and trade in materials (see e.g. McCray 1999). It should be emphasized that certain Islamic glass objects found in church treasuries or from archaeological excavations in Venice, and more generally in the Italian peninsula, are actually very few and very peculiar in colour and processing techniques. They probably arrived in Italy at a later time, perhaps during the crusades (Carboni 2011). Searching for the origins of the Venetian glass-making tradition in the contact with the Islamic world is certainly appropriate for some techniques used in the Late Middle Ages (e.g. enamelling), but for the centuries ranging from the tenth to the thirteenth, the archaeological data and primary written sources are very scarce. Indeed, our view of the past is very

interrupted in both chronology and place, which limits any possibility of constructing a coherent overview: we still do not have sufficient data. The current picture of the transition from the natron- to ash-type glass composition seems to argue for a continuity of production, even if it is one based on the recycling of ancient cullet (Uboldi and Verità 2003). Although scarce, findings of glass objects are reported from early medieval excavations in the Venetian area: San Pietro di Castello (not published) and Sant'Ilario (Moine, Corrà, and Primon 2017, 167), and sources also cite maybe three or four glass artisans between AD 982 and 1158 (see Zecchin 1987, 5). In addition to the transmission of techniques and stylistic adulteration due to the movement of artisans, and although it is possible to grasp some points of contact between the later industry of Murano and the early medieval antecedents of Comacchio and Torcello, Murano more broadly

represents an evolution in terms of the luxurious qualities of the goods and the intended consumers of the same: these products held a profoundly different position in the marketplace. Murano shared with Comacchio and Torcello the availability of resources: in the seventh to ninth centuries in terms of direct access to raw materials; and at the end of the thirteenth and in the fourteenth centuries in pure economic terms (Jacoby 1993). However, as far as the seventh- to ninth-century workshops are concerned, the frontier position was the decisive factor in the case of Comacchio, whose glass-ware was a commodity among others and similar to many others. Whereas at Murano the quality of the products (unique, exclusive, luxurious) was ensured by sourcing the best and most expensive raw materials and manufactured according to a highly advanced and protected technological process. The difference between them is starkly apparent.

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