

Fazit

Mit meiner Arbeit hoffe ich Neugier und Sensibilität für die kaum beachtete, unscheinbare Fundgruppe Flachglas geweckt zu haben. Vielleicht auf den ersten Blick weit weniger sensationell als beispielsweise die Beschäftigung mit farbigen Gläsern gotischer Rosettenfenster an den Kathedralen Frankreichs, gibt diese Arbeit anschaulich wieder, wie Glas – das bis ins Spätmittelalter nur den Kirchen, öffentlichen Ämtern und Reichen verfügbar war – als lichtdurchlässige Fensterfüllung eine große Rolle in der Reichsstadt Windsheim spielte.

Als Fazit lässt sich zusammenfassen, dass erstmals ein archäologisch erfasseter, städtischer Glaserbetrieb umfassend und tiefgehend untersucht werden konnte. Die Erforschung der Windsheimer Glaserwerkstatt entpuppte sich in vielen Bereichen als Weg ins Unbekannte. Im Mittelpunkt der Forschungen standen die Tätigkeitsbereiche und Technologie des Glasers, sein Arbeitsfeld und Lebensstandard. Diese Arbeit ist darüber hinaus als überregionaler und berufsübergreifender Beitrag zu werten, denn die Ergebnisse gehen weit über die bloße Weiterverarbeitung von Flachglas hinaus. Insbesondere sind generelle Rückschlüsse auf die Glasformung in den Glashütten möglich, da die vom Glaser abgetrennten Abfallstücke bislang nahezu unbekannte Produktionspuren aufweisen. Diese Herstellungsspuren treten ausschließlich an fertigen Tafelgläsern auf, welche in der Regel verkauft wurden. Da sie nur im Ausnahmefall im Fundgut von Glashütten vorkommen, sind sie in der mittelalterlichen Glashüttenforschung nahezu unbeachtet. Durch diese seltenen Funde konnten neue und bedeutsame Erkenntnisse zur mittelalterlichen Tafelglasherstellung im Allgemeinen gewonnen werden. Im Fokus auf die Existenz solcher städtischen Glasereibetriebe ist zu wünschen, dass zukünftige Stadtkerngrabungen noch detaillierte Einsichten eröffnen.

12. SUMMARY

In the summer of 2000 the remains of a late mediaeval glazery came to light during an excavation of two latrines on the market place of Bad Windsheim: among other things 300 kg of flat glass⁹⁹³, fretted lead and tools. It was the subject of this work to comprehensively investigate this late mediaeval workshop. Applied were, beside archaeological, also scientific, historical, archival and art-historical methods. An interdisciplinary approach made it possible to gain a coherent picture of the workshop.

Handling archaeologically recovered flat glass

As the person responsible for such a large flat glass assemblage of 75,915 fragments⁹⁹⁴ one time and again encounters surprise in the professional archaeological world and the remark „*that is just a heap of glass*“. Mentioning that these „heaps“ consist almost exclusively of window glass, the reactions are even more sceptical.

These prejudices cannot be entirely rejected. In an uncleaned condition, during and after the salvage, the glass find first appeared to be a homogeneous mass of indistinguishable pieces of broken glass. Only the cleaning of the surfaces from the fine latrine slime let details and characteristics of the glass come to light. It turned out that the assemblage held immense potential, because glass exhibits special properties and behaves completely different compared to other materials.

The widespread scepticism described above reflects also uncertainty in handling archaeologically recovered flat glass. It is often not even recognised on excavations as such, because heavily weathered glass is no longer transparent, but opaque, brown, crazed, pitted or friable. Moreover, contrary to hollow glass, flat glass is harder to identify by its form. With a mass find mostly helplessness arises, because the salvage of this sensitive material is a challenge in itself. Hardly any other material can break so quickly and decay irreparably. If glass which is already dried is washed, as is usual with ceramics, this often leads to complete destruction. Glass is extremely sensitive with respect to water, temperature changes and applications of force. Since there are hardly any references on the salvage, cleaning, preservation and storage of archaeologically recovered glass, a large part of this work addresses these problems and offers solutions⁹⁹⁵.

Symptoms of decomposition

However, it is in the decay of the glass, and thus in the corrosion layers, that also its history is stored⁹⁹⁶. The highly varied and inhomogeneous state of preservation of this glass is remarkable. These deviations are explained primarily by the different compositions, for SiO₂ rich glass is in fact much more stable than SiO₂ poor glass. Analyses show that the frequently poorly preserved wood ash lime glasses contain little silicon oxide, due to their very high proportion of potassium carbonate and

⁹⁹³ Wet weight.

⁹⁹⁴ total number of flat glass fragments of the market place excavation.

⁹⁹⁵ See chapter 5. *Finds Recording Strategy*.

⁹⁹⁶ See chapter 5.4. *State of Glass Preservation*. and 6.1. *The Waste Glass*.

lime. The fine fragments of pruned beaker and bull's eye panes with high sodium oxide ratios and a ratio of over 70 % silicon oxide are, however, outstandingly well-preserved.

Despite similar burial conditions, from time to time certain environmental impacts can be determined, leading to specific decomposition phenomena. In individual cases it is even possible to differentiate between atmospheric corrosion on windowpanes which were actually used and such decompositions which developed during deposition in the ground. To emphasise is typical streaked corrosion, which is recognised for the first time as characteristic of archaeologically salvaged glass. On church windows that are still in-situ this decomposition pattern is atypical and unknown.

Production traces for the shaping of glass in the glassworks

On the other hand - and only apparently contrary to its susceptibility - stands „the memory ability“ of glass. Manufacturing processes on the ductile glass, which took place in the supplying glassworks, have been virtually frozen. A multiplicity of tool impressions and other traces outlasted the centuries unaltered until today⁹⁹⁷. These characteristics particularly represent, in the present work, the basis for the study of the cylinder blow moulding technique.

Two new, completely different and independent approaches could be completely reconstructed⁹⁹⁸:

1. Production flow A, a forerunner of mass production, aims at saving time. With pinching tools the soft glass balloon is held and cut open. Clear deficiencies in the quality of the goods are accepted (fig. 52, p. 128).
2. Production flow B is a time consuming, but nevertheless practicable procedure to manufacture high-quality sheet glass (fig. 53, p. 129). It is surprising that certain hafting marks conclusively prove the strongly disputed centrally attached pointil from Theophilus Presbyter of the 12th century.

The reasons for these late discoveries lie in the above mentioned prevalent scepticism in relation to assemblages of flat glass and in the rarity of some of the manufacturing features:

The present quantity alone causes an increase of some rare characteristics, which are not recognised with smaller find assemblages, since they only occur as singular phenomena or not at all. For example certain pincer impressions⁹⁹⁹ could only be identified as such, because the very complex structures occurred more than thirty times and thus can not have developed accidentally. Compared to the total number of almost 75,915 flat glass fragments of the market place excavation this is,

⁹⁹⁷ See chapter 6.2.1. *Traces of Tools in Malleable Glass (Glassworks)* and 6.2.2. *More Production Marks in Malleable Glass (Glassworks)*.

⁹⁹⁸ See chapter 6.2.4.a) *Pane Glass Production in the Supplying Glassworks*.

⁹⁹⁹ See chapter 6.2.4.a) *Production Process A, a Precursor of Mass Production (Fig. 52)*.

however, a very small number. The recognition and interpretation as production traces, achieved for the first time in this work, as well as the assigning to individual work procedures offer a broad comparative basis for future scientific study of the cylinder blow moulding process.

Manufacturing marks and tools for the subsequent treatment of flat glass in the glazery

Manufacturing traces on ductile glass can be proven in the workshop inventory of an urban glazier only because they were to be found on the finished sheet glass. The craftsman purchased the panes and continued to process them. Due to the absence of production waste and glass shaping tools in the find repertoire it is impossible that he worked the glass in a malleable state. Entirely different traces bear witness to his work: Applications of force to the hard glass, which lead to a crack or a scarring of the surface, endure and are still detectable today. Provided that it does not concern coincidental damage but rather intended action, they stem from the mediaeval glazier's workshop.

The tool inventory in its entirety represents a rarity in archaeology. Since so far no comparable works on finds are published, it was necessary to develop one's own and new methods¹⁰⁰⁰. For characteristic small wasters, which result from being levered off with glazier's pliers, the term *Abhebelreste* was introduced¹⁰⁰¹. From their characteristic form a typological scheme could be sketched for the first time. Considerations were made as to the exact approach of the glazier like the working direction. During the study of a craft activity it became apparent that a purely theoretical perspective quickly reaches its limits. A craft only becomes understandable per se if it is implemented. Scratches, crack lines and edge inclinations let themselves be reconstructed experimentally by me on the basis of recreated tool replicas (flint flake, glazier's pliers and separating tool)¹⁰⁰². The reconstruction of the subsequent treatment of flat glass on the basis of the available manufacturing traces on the flat glass finds could be examined and refined by practical experiments. The written tradition (particularly Theophilus Presbyter and Diderot/d'Alambert) also supplied important information.

Through the interplay of these three sources of information the following single steps of the glazier can be reproduced exactly (fig. 54, p. 263)¹⁰⁰³:

¹⁰⁰⁰ See chapter 6.2.3. *Traces of Tools on Solid Glass (Glazier's Workshop)*.

¹⁰⁰¹ See also chapter 1.3. *Terms*.

¹⁰⁰² On the production traces, which were added to the ductile glass, thus accrued already in the glassworks, so far no experiments could be made. The practical proof of the theoretical explanation models offered by me is much more complex: Glass must be melted and among other things be manipulated with the blowing iron whilst hot. The high temperatures necessary for melting and the following processing can be realised only in special furnaces. Practical experiments would be if necessary a possibility for future projects in co-operation with experienced glass blowers. Particularly, new insights could be gained about the difficult to interpret colourless multi-layer and flashed glasses. Also with the pinch and clamp marks already mentioned an experimental proof would create clarity over the work sequence and the advantages of process engineering.

¹⁰⁰³ See chapter 6.2.4.b) *The Processing of Flat Glass in the Glazier's Workshop*.

1. The hot separation iron was suitable for dividing larger panes.
2. Smaller pieces could be broken at a scratch over edge.
3. Frequently the glazier did without breaking over an edge, particularly in the area of thickened rounded fused rims. Preferably he levered off controlled pieces with the glazier's pliers at a broad crack zone.
4. Likewise with the glazier's pliers occurred the fine shaping and/or the final retouching of the edges.

Coloured and painted flat glass

The available flat glass assemblage does not only consist of simple, colourless to greenish window glass, also intentionally coloured and painted glass sherds occur¹⁰⁰⁴. Scientific analyses inform about the colour additives of the vitreous mass and the type of applied painting. The rare proof of etched black or red enamel in combination with cold painting succeeded. The ultraviolet activity of the cold glaze speaks for a fluorescent animal glue or white lead application. A challenge is the stylistic classification of the altogether 394 painted pieces of broken glass. Each painted fragment is almost always to be interpreted as a singular object. They obviously were collected by the glazier over the years. Although only small details of the former decorative windows are documented, a comparison with the glass paintings still existing in churches today is worthwhile. Especially the figurative paintings, but also the ornaments, provide information to stylistic influences and dating. To emphasize are finds of coats of arms: the coat of arms of the Hohenloher and probably the first coat of arms of the imperial city of Windsheim. They can be linked with an archivally documented commission of the glazier's workshop of 1414, which indirectly refers to glass painting as an implementing activity of the glaziery.

Archival documentation of the workshop

It is a stroke of luck that exactly this archaeologically recorded glazier's workshop is reflected in the written sources. The entries in the early municipal books of accounts range from 1393 to 1451¹⁰⁰⁵. Not only do they limit the possible period of the closure of the family business to a few years, they provide also a concrete insight into the situation concerning commissions, the generation succession, and the standard of living.

Other finds from the glazier's workshop

From the practise of the handicraft witness a possible scratching tool and glazier's pliers¹⁰⁰⁶. As archaeological finds they both rank among the rarities. But the possibilities for the study of the Windsheim glazier's workshop are thereby not

exhausted: Remains of the lead lattice give information about the procedure of the leading-in of the flat glass segment¹⁰⁰⁷. The fretted lead was cast and reworked with a simple tension iron, a plane, a slit wooden strip or a knife. The working marks on the surface do not under any circumstances stem from a lead mill, which as a rule was only introduced in the second half of the 15th century. Casting cake, soldering wire, and old lead prepared for the melt, proves that the glazier manufactured fretted lead. Furthermore, the scientific verification of linseed oil putty, which was brought in for stabilisation between glass and leaden groove, succeeded. Until now the use of putty in the Middle Ages was doubted or completely denied. A triangular clay crucible can be interpreted, on the basis of the analysis of the adhering coatings on its inner wall, as a preparation container for glass painting and possibly for putty¹⁰⁰⁸.

In addition appear „associated finds“ like bull's eye panes and hollow glass ware, which the glazier's workshop did not produce itself¹⁰⁰⁹. Particularly the hollow glass ware provides important dating information (see below). Several pictorial sources show that glaziers generally used or sold glass roundels and hollow glass ware as finished products. The manufacture of bull's eye panes and the in-shop sale of hollow glass products could have also belonged to the activities of the Windsheim glazier's workshop. Archaeologically however, this interpretation is not verifiable; the interpretation as accumulated pieces of waste glass is also possible.

Vocational specialisation

The scientific evaluation of the finds for the first time allows a comprehensive insight into the functioning of an urban mediaeval glaziery workshop. For the first time a coherent – empirically proven – picture can be presented of the processing and the typology of flat glass as a historical building material. The finds prove without a doubt a vocational specialisation in the processing of flat glass¹⁰¹⁰. Glass melting and forming, however, surely did not take place in the workshop, because melting pots, blowing irons, semi-molten batches, blow pipe toppings, glass droplets etc. are absent.

Besides the glazier possibly earned his living through the sale of glass beakers and bottles as finished products, as shown by the accompanying hollow glass finds. Thus for the late mediaeval Windsheim a strict vocational and spatial separation of the out of town glass forming from the processing of flat glass and probably the sale of hollow glass in the town centre is clearly established. The development of vocational separation seems to begin generally in the late Middle Ages. In the years before, the examples of glass production being disconnected from the glass

¹⁰⁰⁴ See chapter 6.4. *Colourings of the Vitreous Mass*.

¹⁰⁰⁵ See chapter 9.2. *Identification of a Family Glaser on the Basis of Surviving Written Documents*.

¹⁰⁰⁶ See chapter 7.1. *Special Glass Finds: Scoring tool?* and 7.5.1. *Grooving Iron*.

¹⁰⁰⁷ See chapter 7.4. *Lead Finds*.

¹⁰⁰⁸ See chapter 7.6. *Triangular Ceramic Crucible*.

¹⁰⁰⁹ See chapter 7.3. *Bull's Eye Panes* and 7.2. *Hollow Glass*.

¹⁰¹⁰ See chapter 9. *Craft, Trade and History of the Glazier's Workshop* particularly under 9.1. *Area of Responsibility and Manufacturing Methods of the Glazier*.

forming increase¹⁰¹¹. Enterprises, which formed the glass hot, could have also been responsible for the „cold“ processing and the installation of the windows¹⁰¹². The glazery in Windsheim is, however, to be classified as a purely urban, firmly residential craft enterprise - without a direct connection to the glassworks. It was supplied by mobile middlemen.

Localisation

There are some clues as to the location of the workshop¹⁰¹³. Since it concerns exclusively the discarded inventory, the building itself is archaeologically undocumented. Much speaks, however, for the fact that it must have lain directly north of the latrines (fig. 105):

1. According to the archives the glazier lived within the town (inner town).
2. The infilling of latrine K5 with glass happened from the north.
3. On the adjoining northern area of the former district court building eight latrines with flat glass were exposed in 1999. The latrine situated closest to the market square likewise contained waste from glass processing.

Dating

The dating of the assemblage is unmistakable from the archaeological sources¹⁰¹⁴. Particularly the painted sherds of flat glass and the hollow glass ware in the workshop assemblage mainly date from the 14th up to the mid 15th century. Some painted decorations are even earlier. This is confirmed by the stratigraphy and building sequence of the formerly densely settled area as well as by 36 written references of the enterprise between 1393 and 1451. The end of the workshop can be narrowed down by the last mention from 1451. The massive glass packages in both latrines can be interpreted as a *closed find*. So the glass had been probably filled in one-time after 1451. The find of the glazier's pliers amongst the flat glass indicates that the workshop was indeed abandoned. The disposal of this special tool speaks for the fact that the last glazier could no longer exercise his occupation or died.

Open Questions

Some questions must remain unanswered despite extensive and in-depth investigation: How are the 394 painted fragments in the glass fill to be explained? Which paintings were made by the Windsheim workshop? When are the painted

pieces to be counted as accumulated waste glass resulting from repairs?

Space for speculation is provided also by the fact that such a large quantity of glass and fretted lead was disposed of at all and not recycled: Was the material value so low that transport and recycling would not have been worthwhile? Or were there no glassworks in the proximity, which would have accepted the glass? Possibly many glassworks generally used only „in-plant“ waste, because the mixing proportions with non-local waste glass would have been hard to control.

The localisation of the supplying glassworks turned out to be unsolvable, because written records concerning the trading relations of the Windsheim glazier to dealers do not exist. A small chance would still lie in a future comparative element analysis of glasses from the workshop find with those of individual glassworks, for example in the Spessart¹⁰¹⁵.

This shows that flat glass in general and its production and subsequent processing in particular offers enormous potential for future scientific research.

Conclusion

With my work I hope to have aroused curiosity and sensitivity for the hardly considered inconspicuous group of flat glass finds. Perhaps at first sight far less sensational than for example the occupation with coloured glass from gothic rosette windows at the cathedrals of France, this work clearly demonstrates how glass - which up to the late Middle Ages was available only to churches, public offices and the rich - as a translucent window filling played a large role in the imperial city of Windsheim.

In conclusion it can be summarised that for the first time an archaeologically documented, urban glazery enterprise could be examined comprehensively and in-depth. The study of the Windsheim glazier's workshop turned out to be in many fields as a way into the unknown. Central to the research were the activities and the technology of the glazier, his sphere of work and standard of living. This work is further to be rated as a supraregional and trans-occupational contribution, because the results go far beyond the mere processing of flat glass. In particular general conclusions on the forming of glass in the glassworks are possible, since the wasters separated by the glazier exhibit production traces that were hitherto almost unknown. These manufacturing traces occur exclusively on finished sheet glasses, which were usually sold. Since they occur only rarely in the assemblages of glassworks, they are almost neglected in mediaeval glassworks research. New and important insights could be obtained from these rare finds for mediaeval sheet glass production in general. Focussing on the existence of such urban glazery enterprises it is to be desired that future inner town excavations open up more detailed knowledge.

¹⁰¹¹ One factor was probably that for molten glass temperatures far higher than 1000°C were necessary, whilst the forming itself required only about 700°C. This took place up to the introduction of the combined fuel oven in separate ovens and often in separate enterprises: see also in detail Loibl 2003, 11–15.

¹⁰¹² Scoring tools and glazier's pliers on glassworks excavations in the Nassach valley show that even in the 15th–16th century the processing of flat glass could still take place in its surroundings: see Lang 2001, 92, 165 Taf. 9,3; 174 Taf. 18 under. – Lang 2003, 101.

¹⁰¹³ See chapter 8.2. *First Indications to the Localisation of the Workshop* and 10.2. *The Area of the Former District Court Building under 10.2.1. Remains of Glass Processing and Further Indications to the Localisation of the Workshop*.

¹⁰¹⁴ See chapter 8.3. *Dating the Inventory of the Glazier's Workshop*.

¹⁰¹⁵ Analyses would first have to be made from many glassworks locations. In the case that non-local waste glass was added to the mixture it would be difficult to find suitable reference material. The raw material additions within an enterprise would then differ greatly. From written tradition it is to be learnt that broken glass was a commodity that was in demand: see notes 100.