

SUMMARY

GLASS FROM ARCHAEOLOGICAL EXCAVATIONS

Archaeology, technology and survey methods, conservation and restoration

Glass and glass products are a permanent part of the archaeological record from prehistoric times up to the Modern period. Under normal conditions, it is a very fragile material that breaks, corrodes and subsequently disintegrates quite easily. Hence, in order to obtain as much information as possible from glass finds, it is necessary to treat them with systematic care, beginning with the identification and retrieval of glass artefacts during archaeological excavations, their documentation, scientific analysis and conservation and, the preventive care placement in a museum depository or exhibition hall. This collective monograph entitled *Glass from Archaeological Excavations* and with the subtitle *Archaeology – Technology and Methods of Survey – Conservation and Restoration*, includes three more or less separate sections focussed on the history of glass production and its reflection in archaeological sources, the qualities of glass and the methods of its study, and the methods employed in the care of glass artefacts from archaeological excavations. The publication is composed as a practical manual intended for all archaeologists who come into contact with glass during their work in the field. It will also be useful for museum and laboratory workers taking care of historical glass and, in a broader sense, university students studying archaeology and art history, not to mention members of the general public interested in this subject.

A / ARCHAEOLOGY

A1 HISTORY OF GLASS PRODUCTION

A1.1 Production and processing of glass

The cradle of glassmaking, one of the oldest crafts, was the Near East, from where the oldest reports are known from as early as the 3rd millennium BC. The production of glass was preceded by knowledge of glazes and faience (fig. 1). Glass artefacts made from plant ash glass and, after 800 BC, also from natron glass, were imported to prehistoric Europe from Mediterranean workshops. An exception in the Late and Final Bronze Age (12th–11th century BC) is glass beads, apparently produced in northern Italy from a different type of glass – mixed alkali glass.

The oldest beadmaking techniques include winding on a core, drawing and cutting; the mosaic technique was introduced later, and the Roman Period marked the advent of glass blowing (tab. 1). In addition to beads and small ornaments, vessels are represented in the assortment of goods from processing workshops in the Mediterranean since the middle of the 2nd millennium BC; these came to the European continent later, in the 6th–5th century BC. A major chapter in the history of European glassmaking was the La Tène period (the production of glass is typically attributed to the Celts). However, production locations are identified only on the basis of finds of raw glass and glassmaking waste, or a higher concentration of finished products. Němčice nad Hanou in Moravia (Venclová 2016) is an illustrative example. The local production of glass in Bohemia and Moravia was interrupted for a long period after the demise of La Tène culture. In the Roman and Migration periods (1st to mid-6th century AD), all glass artefacts, i.e., beads, other ornaments and also vessels, were imported from Roman provincial workshops, in rare cases from even more remote production areas.

In the following centuries, especially from the Carolingian period, structural and technological changes occurred in European glassmaking. Glass was not melted from primary materials in Bohemia and Moravia between the 6th and 12th century, and it is likely that not even secondary glass centres existed prior to the year 800 AD (Košta – Tomková 2011). But even after that date, the majority of our glass finds (especially small ornaments, less often hollow and window glass) were imports from either European workshops or more remote production areas in the Near East. The chemical diversity of glass is typical for this period, and in addition to soda glasses, lead, mixed and potash glass are also documented (Černá – Tomková – Hulínský 2015).

The domestic production of glass from primary raw materials is not safely documented until the High Middle Ages, sometime around the mid-13th century. Glassworks were founded in mountain regions, where they created separate production circuits (Černá 2016). Their assortment includes hollow glass, mainly high and low beakers with prunts, and crown glass and plate glass for windows. Until the middle of the 14th century, imports from soda glass made up the majority of artefacts in settlement assemblages. Over time, however, domestic products made of potash-lime glass predominated. Starting in the 14th century, 'Bohemian' glass was recognised for its high quality even on foreign markets. The same was true in the Modern period (from the 17th/18th century), when it successfully competed with Venetian products. In the period from the 18th century to the mid-20th century, domestic glassworks used innovative production technology and methods, including new forms and decoration. The period witnessed an expansion in the production of utility glass, lighting fixtures, glass costume jewellery and mirrors, intended mainly for export, as well as flat, container and optical glass for the domestic market.

A1.2 Glassworks and the production of glass

Due to its specific nature, glassmaking stands out from the spectrum of other crafts with its demanding production technology and specific production organisation (fig. 9). Glass production involves three to four phases: melting (single- or multi-phase), creating and cooling the products, as well as any possible finishing work (painting, etching, grinding, etc.). The melting of glass from raw materials took place in 'primary' production centres that typically operated separately from processing workshops, otherwise referred to as 'secondary' centres. Primary glass production centres did not exist in Bohemia and Moravia during prehistoric times or the Early Middle Ages. On the other hand, processing workshops producing small ornaments from imported raw glass are documented, first from the La Tène period (Němčice nad Hanou, cf. Venclová 2016) and then, following a longer pause (up to the year 800 AD) verifiably in Moravia and apparently also in Bohemia (Košta – Tomková 2011, 335–337). The fact that no production features have been discovered to date makes it impossible to know exactly how these workshops were furnished. Knowledge of glass melting reached Bohemia around the mid-13th century (most recently in Černá 2016). Newly arriving glassmakers built their furnaces in the mountains, areas previously unsettled but highly favourable for operating glassworks due to the local abundance of the necessary raw materials (quartz and wood), the proximity of water sources and good climatic and geomorphological conditions. High medieval glassworks are referred to as forest glassworks (*Waldglashütten*) or travelling glassworks (*Wanderhütten*), since the high consumption of wood (for heating the furnaces and producing potash) meant that they had to be frequently moved from deforested areas to new sites in the proximity of more trees.

In the 13th–15th century, glassworks joined together to form production circuits (fig. 4), each of which had at least two types: 1. the main glassworks – *parent* and 2. subsidiary – *daughter*. In the first type, glass was melted from primary raw materials, made into products, and workers probably also lived at these sites. Glassworks of the second type were exclusively for production purposes (Černá 2016). In neighbouring Germany, glassworks are known with only one furnace (*Ein-Ofen Anlage*), in which only raw glass was apparently melted (Leiber 2012). Medieval glass furnaces were built from stone and heat-resistant clays, without a foundation. Their original appearance cannot be unambiguously reconstructed, and it is only possible to distinguish the main melting furnace from smaller auxiliary furnaces. Changes in the size and layout of both of these types of furnaces can be traced over the course of three centuries (fig. 5). Furnace development continued in the Early Modern period, especially with melting furnaces, which, compared to medieval versions, were larger and had a more intricate ground plan. The appearance of the furnaces and the wooden structures (melting hall, small shelters, etc.) is documented by archaeological finds and written, iconographic and a small number of cartographic sources (Černá 2016). Medieval glassworks were situated in the open landscape, far from other settlements. Their location is difficult to pinpoint, as the places of furnaces appear in the forest as slight mound-like elevations (fig. 7). The identification of the location of glassworks is also aided by movable objects – artefacts connected to the production of glass (fig. 10) as well as glassmaking waste. Conversely, the remains of Modern glassworks are often found in the built-up area of villages, either in open space or covered by later development.

A2 METHODS OF ARCHAEOLOGICAL INVESTIGATION

The objective of archaeological investigations in the field is to gain information on the context and artefacts located on the surface (terrain remains) and, especially, beneath the contemporary surface. Non-destructive forms of investigation are used primarily during the initial survey and localisation of the production centres of glass (glassworks) in the open or forest landscape. The most common of these include surface surveys and collections, followed by detailed geodetic documentation, detector

surveys and geophysical measurements (fig. 12, 13, 14). Three-dimensional mapping of the surface using aerial LiDAR, laser scanning or LiDAR imaging, remains rare for now (*Brejcha 2013*).

Destructive methods include classic excavation involving the gradual uncovering of the archaeological situations by natural layer, from the stratigraphically highest to the lowest, typically down to the level of the natural subsoil. The foundation for each excavation is visual documentation of the examined contexts and their precise topographic survey. Finds (including glass artefacts) are removed from the examined contexts and recorded in a way that permit their precise connection with the documentation acquired for the examined site. Capturing spatial contexts is a fundamental prerequisite for the future dating of the find and subsequent processing, including conservation-restoration work. A high-quality excavation also requires knowledge of the possible composition of glass finds in connection with individual historical periods and their potential appearance in studied archaeological situations (fig. 15). Basic find environments include settlement (settlement features such as pits and wells, fig. 16, 17, 18), production (defunct glassworks, fig. 19, 20, 21, 22) and burial areas (inhumation cemeteries and tombs, fig. 23, 24). In general, it is possible to state that the field investigation of archaeological situations and features with glass artefacts is no different in terms of methodology than other archaeological activities involving interventions in the terrain.

A3 WHAT WE FIND

A3.1 Prehistory and the Migration Period (from 2300 BC to the 6th century AD)

Attention is drawn in the chapter's introduction to the impact of archaeologisation processes on the frequency and preservation of glass artefacts. The Bronze Age in Bohemia is characterised by beads, which were made in the Early Bronze Age from faience, from the Middle Bronze Age from glass. In the Late and Final Bronze Age, in the 12th–10th century BC, beads were made from mixed alkali glass produced in northern Italy (fig. 25, 26; *Venclová et al. 2011*). We first encounter soda glass in the Hallstatt–Early La Tène period in the 8th–5th century BC. Soda ash glass was soon replaced by soda lime natron glass. The range of glass artefacts, almost exclusively imported, expands in this period. Beads (fig. 27) were worn, including on metal torcs, earrings and fibulae; glass pin heads and glass fibula bows also appear. Beads with blue-white eyes (*Venclová 1990*) are the leading type of bead in the Final Hallstatt period and the Early La Tène period in the 6th–5th century. Glass rings are a new type of artefact and small polychrome core-formed vessels appear in rare cases.

An extraordinary chapter in the history of glass from the middle of the 3rd century BC to the 1st century BC is La Tène ('Celtic') glass-working with a specific assortment of products without parallel outside La Tène Europe. These are bracelets, ring-beads, small rings and spacers (fig. 28–30; updated classification system used in this country today: *Venclová 2016*). The glass is still soda lime natron glass made in Egypt or the Near East, which was further processed upon reaching Europe. The largest collections contain hundreds of specimens, and the overall number of products in La Tène Europe is estimated to be in the tens of thousands. The workshop in Némčice in Moravia is the best documented site thus far (*Venclová 2016*). Final products there are accompanied by raw glass, semi-finished products, failed pieces and other waste unknown from other sites (fig. 3). Hellenistic vessels (fig. 31; *Venclová 2016*; *Venclová et al. 2015*; *2018*) and finger-rings with glass gems were imported.

The Roman and Migration periods (1st century AD to the mid-6th century AD) again provide beads, though in a new formal and colour range (fig. 32; basic classification: *Koch 1977*; *Tempelmann-Maczyńska 1985*). These initially reached central Europe from Roman workshops, later from provincial production sites. Their soda lime natron glass was imported, but recycled glass, apparently from local European workshops, was also used. Bead finds increase significantly as of the Late Roman Period (from the 3rd century AD onwards). Large specimens found separately, very small seed-beads and segmented beads are noteworthy. Glass was also used to produce simple bracelets, glass gems and inlays of metal artefacts, gaming pieces and stirring rods. The frequency of glass vessels gradually increases. Mosaic and cast ribbed bowls were popular in the Early Roman Period, though the number of blown vessels continues to increase. These are flasks, jugs, unguentaria and bowls, whereas goblets are typical for the Migration Period (fig. 33–34).

A3.2 Early Middle Ages (6th–12th century)

In contrast to the previous period, the Early Middle Ages are characterised by great diversity in the chemical composition of glass accompanied by the typological variability of artefacts, the spectrum of which changed in Bohemia and Moravia in the 6th–12th century in connection with various factors, e.g., involvement in interregional and long-distance exchange stretching to

the eastern Mediterranean and the Middle East, eastern and western Europe, as well as cultural and social transformations such as a change in the burial ritual and, starting in the 9th century, Christianisation.

While a relatively broad scale of imported monochrome and polychrome beads from the late phase of the Migration Period are observed at cemeteries in Bohemia and Moravia in the first half of the 6th century, this range narrows in the following period up to the mid-9th century in connection with an overall drop in the number of finds. The Early Slavic period is represented mainly by monochrome beads from the settlement in Rostoky (6th–7th century). With only a few exceptions in the form of segmented beads, different types of beads occur in the 8th century and the first half of the 9th century, more frequently in Moravia than in Bohemia, where only individual specimens are documented.

The 9th and 10th centuries are marked by heavy growth in the number of finds, and the spectrum of glass artefacts also expanded. At this time, they were mainly made from soda lime natron glass and plant ash glass (*Tomková – Jonášová – Zlámalová Cílová 2017*). Mixed alkali glass and, from the 10th century onwards, high-lead glass, appear only marginally, and potassium (wood ash) glass of probable Carolingian origin is very rare (fig. 35). Monochrome beads dominate, their numbers far exceeding their polychrome counterparts (fig. 36, 37). The spectrum of ornaments is supplemented with glass gombiks hemispheres (fig. 38). Glass was also used as a fill in metal ornaments, gombiks, finger-rings (fig. 38:1,2), fittings and kaptorgas. Finds of hollow glass include goblets, beakers and small bowls (fig. 38: 5, 39). Fragments of lamps, window glass in the form of monochrome and decorated panes (fig. 38: 3) and smoothing tools (fig. 38: 4) are known only from Moravia. Finds of glass artefacts reflect more advanced development in Moravia in the 9th century, followed by dynamic growth in Bohemia from the end of the 9th century and especially in the 10th century. In both Moravia and Bohemia, the local production of certain types of beads (or other objects) using imported glass can be expected.

The 11th and 12th centuries were witness to a major transformation in the spectrum of glass artefacts, the frequency of finds of certain types of objects and in the representation of chemical types of glass (fig. 35). The leading position in Bohemia and Moravia was held by ring ornaments, finger-rings, finger-rings/rings and rings from lead glass, high-lead glass and lead-ash glass (fig. 40; *Havrdá – Tomková 2020; Sedláčková – Zapletalová 2012*). The share of their central European production compared to imports from distant regions is impossible to determine today. The number of imported artefacts from soda glasses decreased, especially soda lime natron glass, and artefacts from wood ash glass are also marginally represented (*Černá – Tomková – Hulínský 2015*). Beads, the typological range of which narrowed and partially changed from the earlier period, recede into the background (to a greater extent in Bohemia than in Moravia). Hollow glass represented by shards of beakers, bottles and indeterminate forms is documented thus far only rarely in the find inventory. The same is true for window glass, which appears in only a small number of cases, and only in fragments (*Černá – Tomková – Hulínský 2015*). The spectrum of finds from the 11th and 12th centuries is supplemented by mosaic cubes and fragments of bracelets (*Černá 2007*).

A3.3 Glass of the High Middle Ages (13th–15th century)

Archaeological glass finds reflect economic and cultural changes in the Czech Lands in the High Middle Ages. Compared to previous periods, decorative objects decreased; conversely, the number of vessels grew. While glass was still rare at the beginning of the 13th century, from the second half of the 13th century it gradually reached even the lower social classes (*Černá 2000 b, 47*). This period is characterised by significant formal variability and the wide-ranging provenance of finds. The palette of forms includes imported low beakers with smooth vertical ribs (blown into a mould) and domestic products with melted threads, both smooth and those decorated with grains of other colours (fig. 41: 4, 5; 42). Low beakers with prunts were also popular (fig. 41: 1, 2; 43). Vessels were made from glass of different chemical compositions depending on where these products were made. Domestic products and those from neighbouring central European glassworks are characterised by wood ash glass. Products from plant ash glass and, in exceptional cases also high-lead glass, were imported from more distant glassmaking centres in the south, southeast and southwest of Europe. To a lesser extent, we also encounter beakers with horizontal threads (fig. 41: 6, 8), optical decoration (fig. 41: 7) and smooth walls (fig. 41: 9). Bottles with a body-tubular ring in several variants are also represented (fig. 43: 24; 50). Flagons (fig. 47) and cups also occur in small numbers (*Drahotová et al. 2005, 88*). Luxury goods included vessels painted with enamel or gold (fig. 41: 21, 32; 44, 45), which were imported here from the south and southeast of Europe or the eastern Mediterranean (*Černá – Podliska 2008*). Window glass is represented by many shards of monochrome or painted panes, and beads, rings and, very rarely, smoothing tools also occur (fig. 48).

In the 1300s, especially in the middle of this century, there is sharp growth in the amount of glass in the urban environment,

testifying to the fact that glass vessels became an integral part of the furnishings of burgher households. The majority of finds are products from potash lime glass of domestic provenance, whereas imported specimens are made from plant ash glass. All previously known basic vessel variants are documented, albeit often in modified form: low beakers with prunts, beakers with drawn droplets, bottles with a pear-shaped body (fig. 41: 22), bottles with vertical ribs (fig. 41: 23; 50), and flagons (fig. 41: 28, 29; 47). Tall beakers with prunts known as 'Bohemian-type beakers' became for our territory a characteristic form that occurred in many variants (fig. 41: 12–20; 51). Kuttrolfs (fig. 41: 25, 26; 52) and jugs (fig. 41: 30, 31) newly appear, and hanging lamps also occur in small numbers (fig. 41: 36; 49). In addition to hollow glass, we also encounter window glass to a lesser extent and, quite exceptionally, mosaic glass.

The described development also continues in the 15th century, especially its first half. The output of domestic glassworks is high and assemblages of medieval glass are sufficiently rich. These are characterised by formal uniformity and are composed primarily of vessels of domestic provenance. All of the forms used in the preceding period continue, with Bohemian-type beakers remaining the leading form. Krautstrunk (cabbage stalk) beakers with flat applied drops appear (fig. 41: 3), as do a small number of specimens of sanitary glass such as flytraps (fig. 53), breast pumps and even whimsical vessels, e.g., in the shape of a shoe (fig. 54). Although a decline in the number of glass finds is apparent in Bohemian towns beginning in the second half of the 15th century, the situation is different in Moravia, where rich assemblages have been found (*Sedláčková et al. 2018*, 146).

A3.4 Early Modern period (16th–17th century)

Early Modern period glass was characterised by its morphological variability. Hollow glass (table, technical, container, sanitary) appears in the greatest numbers. Cylindrical and conical beakers are among the most widespread types of products (fig. 56: 1–9). A typical Early Modern variant is a higher beaker on a bell-shaped foot (humpen), which can be decorated with enamel and gold painting. A creatively developing form is goblets, most often with a semi-ovoid cup and a stem shaped in various ways (fig. 56: 10–17). The production of variants with a high and densely shaped stem decorated with wings and prunts began in the mid-17th century (fig. 56: 16). Lids could be possible accessories to beakers and goblets. Steins with a strap handle appear from the middle of the 17th century (fig. 56: 25). Bowls and plates are represented in smaller numbers (fig. 56: 23–37). Flagons and jugs are formally and functionally similar vessels with a handle (fig. 56: 18–21). Bottles of various sizes and vials are the most heavily represented glass products (Fig. 56: 26–31, 36). Whimsical vessels are specific products (fig. 56: 40–41). Laboratory glass was represented by the glass parts of distillation apparatuses, vials and small, thin-walled bowls (fig. 56: 32, 35, 38).

Flat glass is divided into two groups – window glass and mirrors (fig. 66). A typical representative of window glass is the flat disks of crown glass. The smallest group of products is composed of small items such as rings, finger-rings, spheres and beads.

A wide range of decorative techniques were used (fig. 67: 1–19). Decoration created directly at the glassworks during the processing of glass included stamp imprints, threads and blowing the basic shape into a mould. The most widespread decorative element is optical decoration created by blowing into a mould followed by shaping. Filigree decoration is created by melting polychrome (typically opaque) rods into clear glass. Stems with inserted coloured threads appear in the mid-17th century. Other decorative techniques include engraving (cutting), grinding, painting (with enamel from the mid-16th century; 'cold' from the 17th century) and gilding. Gilding appears on its own or in combination with enamel painting. In rare cases, find assemblages contain chalcedony and millefiori glass.

A3.5 Modern period (18th–20th century)

Modern period glass production in the Czech Lands is very diverse. The range of offered goods expands sharply, new fields and specialisations emerge, technological processes are innovated and old ones are renewed. In addition to traditional manual production, mechanisation is employed and production facilities are modernised. The text addresses the characteristics of the period, with an emphasis on the fundamental changes that it brings. The greatest attention is devoted to utility glass (fig. 71–77) and glass costume jewellery (fig. 80–81), and lamps, optical glass, flat glass and container glass are mentioned contextually (fig. 78–79, 82). A special focus is the general typology of glass, technologies that were employed and their chronology. In the vast majority of cases, finds from this period are studied today on the basis of items from museum collections. The archaeological research of finds from the relevant period is only in the early stages today.

B/ TECHNOLOGY AND SURVEY METHODS

In its introduction, Part B focuses on technology and information on individual historical periods, the particularities of glass production and survey methods. It describes the raw materials used, production processes and fundamental properties of glass, both in terms of its chemical composition and its preservation, and thus also its chemical resistance. It explains the actual process of glass corrosion and other damage which may occur due to the environment (tab. 1). It provides a detailed characterization and visual documentation of the crystalline phases and silica-rich layers which may form on the glass surface. Their differentiation is crucial in deciding on the method of conservation and restoration intervention.

The second section presents possible analytical methods, the results of which are used in the interdisciplinary evaluation of archaeological glass finds. Particular attention is paid to the possibilities of sample preparation (tab. 2), because this step affects the quality of results acquired. Contamination of samples by the environment or the corrosion mechanisms already discussed can affect the surface condition. These aspects must be taken into account during preparation prior to the analysis. In addition to imaging techniques, ranging from optical microscopy to 3D reconstruction, documenting both the artefact itself or its parts, and samples taken for analysis, a substantial section is devoted to the most used instrumental techniques. These techniques allow us to study the chemical and structural composition of the glass, the corrosion products, enamels and colour layers applied to archaeological glass finds. These data are very important from today's perspective of studying historical glass technology. Thanks to the methods which allow us to obtain highly precise and exact data, we can, for example, determine the glass opacifier components, or on the basis of detecting elements even in trace amounts, we can sometimes even determine the provenance or dating of glass artefacts. Examples of the outcomes of individual measurements make an integral part of this section so that the reader obtains a better understanding of the issue.

C/ CONSERVATION AND RESTORATION

Part C provides a comprehensive procedure for the care of archaeological glass from its discovery during excavation to its storage in collections.

C1 ETHICAL STANDARDS AND GENERAL CONSERVATION-RESTORATION PRACTICE

The introduction summarises the main ethical principles of conservation – restoration work, and the difference between preventive and remediation interventions (*Document on profession 2011*). In general, it is recommended to minimize interventions – i.e. to prioritize preventive care over conservation or restoration which introduce modern materials. Particular emphasis is also placed on interdisciplinary co-operation.

The entire conservation-restoration process is a collective activity involving not only conservator-restorers, but also particularly archaeologists, depositary administrators, art historians, glass technologists, chemical technologists, documentalists and other specialists. Only by close co-operation of all experts can the maximum possible information be obtained in the processing and subsequent care of archaeological finds so that they can be preserved for future generations.

C2 BASIC TREATMENT OF GLASS

This part focuses on treatment of glass in the field, i.e. when discovering findings during archaeological excavation. Over time, the artefacts in an undisturbed soil environment, get into a state of equilibrium in which the rate of material degradation falls rapidly and the artefacts are physically preserved (fig. 1). After excavation, however, the ambient atmosphere causes a rapid acceleration in degradation to restart as a result of the materials being subjected to new conditions (*Newton – Cook 2018*). For

further preservation of the items found, it is very important that their excavation is carried out sensitively in order to reduce adverse impacts on the changes in the material base. The difficulty of overall conservation of archaeological glass and the amount of obtainable information depends on the correct execution of the excavation. In most cases, unprofessional cleaning of the glass on site, its storage in inappropriate conditions or incorrect acclimatisation will have a devastating effect on the glass material, whether it is excessive drying and subsequent disintegration of the material, or infestation by microorganisms in an overly wet environment.

This section describes the individual steps how to proceed when a find of glass is made in archaeological situations common for Czech provenance (tab. 2). Criteria such as fragmentation, dispersal of finds at the site, the degree of corrosion damage and the nature of the excavation environment determine further procedures from uncovering, removal and packaging to transfer for laboratory processing. The dampness level of the excavation environment and the level of corrosion damage are considered fundamental, and the more humid the environment and the greater the corrosion damage, the more prone to damage the glass finds are, and therefore require more precise intervention.

The section on the planning of laboratory work describes the standard chronology of laboratory tasks (tab. 4) and the sensitivity of glass to the speed of intervention, i.e. what types of glass need to be processed as a priority and as soon as possible. There is a detailed description of the acclimatisation process, i.e. the very gradual transfer of the glass from the finding conditions to conditions appropriate for long-term storage in a depository. During the work, it is important to respect the find context and the method of marking/labelling glass fragments (fig. 27–29), in order to avoid damage to the glass.

Prior to any intervention, an investigation has to be conducted which focuses primarily on assessing the current condition of the object, the cause and extent of damage and the nature of any previous interventions so that the entire conservation-restoration process can be planned. This investigation is conducted partly during the site inspection, and then immediately after the finds are received at the workplace. On the basis of the investigation made, a plan is drawn up which contains a specific proposed procedure, and is an important basis for the administration of the work. During the course of the finds processing, the investigation can be supplemented by a so-called extended investigation, including analytical methods (Part B).

Conservation and restoration documentation is an integral part of the intervention. Its components are described in a separate chapter, both the text part and the photographic part, which is supplemented by tips on how to take high quality photographs of glass without damaging it.

C3 CONSERVATION AND RESTORATION PROCEDURES

This part deals with direct interventions into the material which are intended to stabilise its physical condition with the least possible impact on its informative value. These interventions include cleaning, drying, consolidation and also bonding and reconstruction.

Cleaning is a core process in conservation and restoration methods. In most cases, it is also a prerequisite for further intervention steps and it is always an irreversible process. Any kind of cleaning is a highly invasive treatment of the glass, and you should always proceed gently and with caution, beginning with the most easily dissoluble dirt such as remains of soil, and ending with resistant insoluble crusts. Over the course of the work, it is crucial to finish the cleaning at the right moment. The text describes a number of procedures commonly used in conservation workshops, alongside illustrative photo-documentation, including examples of the consequences of inappropriate procedures.

If the glass is particularly fragile and friable due to overall corrosion with corroded layers falling off it even under gentle mechanical stress, or if there is a danger that disturbed decorative elements could be lost, then we move on to consolidation – strengthening the material. This is only done when absolutely necessary, since strengthening of the material is done by impregnating the glass material with a suitable product in order to reach its overall stabilisation. Due to the irreversibility of this intervention, great attention must be paid to the choice of consolidant and the method of application. There is also a separate description of the treatment of highly damaged glass removed in a block, where strengthening is performed at the same time it is being taken out of the soil.

After cleaning and possible consolidation, the search for fragments is usually performed. This involves basic assignment of fragments to individual objects on the basis of distinguishing marks. This task requires a lot of time and space. If connectable sets of fragments are found, these objects undergo restoration interventions – bonding and physical reconstruction.

An entire chapter on bonding focuses on the choice of glue and the work procedure, including a list of specific products to be used. It should be remembered that new products are constantly appearing on the market and, therefore, suitable substitutes should always be verified (the problem of historical products is addressed in Chapter 4). After gluing sufficiently preserved pieces together, we can begin the reconstruction of the glass object – presenting it in its whole form, allowing viewers to appreciate its appearance at the time it was made and used. Some of the most widespread methods of reconstruction include physical reconstruction and drawings (nowadays significantly supplemented by 3D digital visualizations). They are all based on high quality documentary sketches, generally created by a professional documentalist (*Jonášová 2012*, 113). The objective of a sketched reconstruction is to indicate the original, no longer extant state of the particular object. In contrast to physical reconstruction, you can work with the probable shape, or produce a number of variants. Physical reconstruction involves the actual reconstruction of the entire shape using extant fragments (or individual beads for personal ornaments). These reconstructions may have a number of appearances, mostly based on the extent of preservation of the glass material. The overall shape can only be reached using additions (construction or aesthetic additions) or can be achieved using supporting constructions, most often made of perspex or glass fibre fabrics. Since archaeological surveys often preserve only a very small amount of glass suitable for physical reconstruction, it is desirable that this task be entrusted to an experienced conservator-restorer. It is a demanding job requiring co-operation with other expert archaeologists, technologists, documentalists, museologists and others, as emphasised in the introduction.

C4 METHODS OF GLASS CONSERVATION AND RESTORATION USED IN THE PAST

Knowledge of the methods and materials used in the past in the conservation and restoration of archaeological glass is essential for the work of museum conservators-restorers, especially for implementation of re-conservation interventions. It is also desirable for museum curators and collection administrators. The used techniques of consolidation, bonding and replacing losses can limit the possibilities for re-intervention, methods of cleaning and setting up the regime of climatic conditions. General knowledge of materials and an idea of their properties (in particular resistance) is crucial also with regard to the method of handling an object and its use for exhibition purposes. Therefore, a separate chapter in the publication is devoted to methods and materials used in the past. It also provides a brief history of the discipline, along with a chronological overview of key publications.

Conservators did not begin to deal with the issue of treating archaeological glass artefacts systematically within the Czech environment until the first half of the 20th century. Old museum collections were significantly expanded by the increasing amount of contemporary fieldwork, and so with the growing importance of this material source, emphasis was placed on the effort to prolong its physical existence. The preserved glass artefacts have generally suffered a high degree of fragmentation with various types of corrosion damage, conditions which are very difficult to deal with even today. Initially, the options for intervention were considerably limited by conservators' unpreparedness to work with this type of material, and most of the finds remained untreated for many years. It was not until the development of synthetic polymers in the late 1950s that changes began to be implemented in the process of treating glass objects. In the 1950s and 1960s, the conservation of corrosion-damaged glass began to be looked at in more detail by a broader platform of experts.

The methods of restoration interventions and the approach to preventive protection were always in line with the technical possibilities, knowledge and availability of materials at the time. In the past, the primary objective of interventions was mainly to reconstruct the shape of the given object and improve its appearance, mainly in order to be able to present it. Attention was often not focused on the reversibility of measures taken, and analytical methods for investigating artefacts were used only to a limited extent.

Despite today's critical perspective on many of the applied procedures, the basic principles in restoration interventions did not differ much from today's practice. Objects used to be degreased, washed, cleaned, rinsed, impregnated/consolidated, bonded and added, too.

As such, each of the steps is given a separate section in the text, in the form of charts (methods of cleaning, consolidation, fixing joints, adding missing parts and physical reconstruction), which gives an overview of documented, formerly applied materials and procedures.

These overviews of historically used methods and procedures are complemented by assessments from today's perspective, with an emphasis on highly problematic interventions.

C5 PREVENTIVE CONSERVATION

This part of the publication discusses the main causes of damage to glass finds and the appropriate protective measures by means of preventive conservation. The objective of these preventive steps is to slow down the degradation processes and to reduce all risks associated with taking a find out of the ground and its subsequent processing, deposition, presentation or transportation.

The main attention is paid to the effects of microclimatic conditions: temperature, humidity, pollutants, light, ultraviolet and infrared radiation. Recommended values are listed depending on the type and condition of glass objects. This section also explains the effect of biological influences, and protection against them. A separate chapter includes protection against mechanical influences, which include handling, packaging and transport. High-risk activities include lending and exhibiting glass objects. For this reason, in addition to the depositary regime, special attention is also paid to protective regimes outside the depositary, including contractual security in loan agreements. The chapter on the administrative delivery of preventive conservation provides brief information on how to ensure protective measures and their observance within an institution.

With regard to archaeological research, preventive care is divided into three main areas:

- a/ preventive conservation during an archaeological excavation, after uncovering the find, and during its transport to the conservation workplace
- b/ preventive conservation after transport to the conservation workplace: during conservation and subsequent professional processing, storage, exhibition, etc.
- c/ conservation maintenance at the site of the long-term storage or exhibition of the objects. Conservation maintenance involves periodic inspection and necessary treatment of objects. In particular, it includes cleaning their surfaces from dust, and from any soluble corrosive products, using remedial conservation. This is done using either a dry or a wet method.

RESÜMEE

GLAS AUS ARCHÄOLOGISCHEN GRABUNGEN

Archäologie, Untersuchungsverfahren und -methoden, Konservierung und Restaurierung

Glas und Glasprodukte bilden einen Dauerbestandteil archäologischer Funde von der Vorzeit bis in die moderne Neuzeit. Unter normalen Umständen handelt es sich um ein sehr zerbrechliches Material, das relativ leicht Fragmentierung, Korrosion und nachfolgendem Zerfall unterliegt. Wenn man möglichst viele Informationen aus Glasfunden gewinnen will, benötigen diese ständige Pflege. Das beginnt mit der Identifikation der Glasratefakte während der archäologischen Grabungen, wird mit ihrer Dokumentation, fachlichen Untersuchung und Restaurierung fortgesetzt und weiter mit Vorbeugende Konservierung während Deponierung in Museums- oder Galeriebeständen bzw. mit ihrer Präsentation in Ausstellungsräumen. Die vorliegende, von mehreren Autoren verfasste Monographie mit dem Titel „Glas aus archäologischen Ausgrabungen“ und dem Untertitel „Archäologie, Technologie und Methoden der Untersuchung, Konservierung und Restaurierung“ umfasst drei mehr oder weniger eigenständige Kapitel. Sie behandeln die Geschichte der Glasproduktion und deren Widerspiegelung in archäologischen Quellen (A), chemische und physikalische Eigenschaften des Glases und Methoden seiner Untersuchung (B) sowie Formen der Behandlung von Glasgegenständen aus archäologischen Ausgrabungen (C). Die Publikation wurde als praktisches Handbuch verfasst und ist für alle Archäologen bestimmt, die bei Ausgrabungen mit besagten Fundarten zu tun haben, für Museums- und Labormitarbeiter, die historisches Glas behandeln, und im breiteren Kontext auch für Hochschulstudenten der Fächer Archäologie und Kunstgeschichte sowie für Laien, die sich für diese Problematik interessieren.