In Situ Glass Conservation:
A Case Study from the Archaeological Site of Barsinia / Jordan

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Abstract: *During the excavation carried out by the Faculty of Archaeology and Anthropology, Yarmouk University, at the archaeological site of Barsinia, northern Jordan, from July 10 to August 15, 2006, a considerable collection of glasses has been uncovered. The preservation of those glasses was important because of their archaeological and technological interests. Recording (photography and drawing in scale 1:1) took place before the lifting and transportation of the glass object to the field laboratory. Special lifting techniques (in block and backing) were applied to these glasses. Initial consolidation with PVA emulsion and bandaging with gauze and plaster were also applied in order to reassure future study and resetting of the glasses. Preliminary conservation of the glass objects included cleaning, consolidation and joining. At first, initial tests were carried out in order to select the appropriate materials. Glass samples intended to be analyzed were kept without conservation treatment. Finally, the treated glasses were packed and stored properly until their conservation is completed in a specialized laboratory.*

Introduction

The Faculty of Archaeology and Anthropology at Yarmouk University started the first season of excavation at the archaeological site of Barsinia, 15 km. to the west of Irbid, Jordan (Fig. 1), under the direction of Dr. Lamia El-Khouri with the cooperation of the Department of Antiquities of Jordan, from July 10 to August 15, 2006. As has been planned, the excavation is considered as field training for the Faculty students. The previous archaeological survey carried out by the Department of Archaeology and the French Institute for Oriental Archaeology in Damascus (IFOA) has revealed the significance of that archaeological site. Moreover, the site of Barsinia has been mentioned in some archaeological studies (El-Khouri et al. 2006).

Excavation works were carried out in three areas of the site representing the residential and tombs areas (Figs. 2 and 3). Excavations uncovered some important monuments and artifacts at the site, such as rooms of building, grinding stones, plastered and paved floors, cisterns for water, pottery sherds, metal tools, glass fragments, and incomplete glass objects. Moreover, rock-cut and built tombs in different shapes and structures were uncovered, in which numerous remains of bones were found. The

Fig. 1: Map of Jordan showing the archaeological site of Barsinia. Source: www.globosapiens. net/country/ Jordan_map_html.

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excavated remains indicate that this site had been settled during the Iron Age, Hellenistic, Roman, Byzantine, Umayyad, Abbasid, Mamlouk, and Ottoman periods in Jordan (El-Khouri et al. 2006).

A considerable collection of glass fragments, beads, and incomplete objects of different typology and colors was uncovered from every digging square and rock-cut tomb. An incomplete bottle was found during excavation work carried out in tomb no.1. (Fig.4). Typologically, it is authenticated and dated to Late Roman or Byzantine period in Jordan (Al-Ahmed and Al-Muheisen 1995). This object appeared to be a good example of freshly excavated glass, on which several first aid treatments could be carried out in the field.

Several studies performed on conservation of archaeological finds confirmed that glass conservation on site is one of the most complicated problems facing conservators, and needs many considerations. According to Leigh (1978) and Newton (1989), on-site conservation consists essentially of the correct lifting, labeling and packing of the glass. Applied studies carried out by Dowman (1970), Cronyn (1990) and Foley (1995) point out that on-site conservation is perhaps the most crucial stage of all the processes of conservation. Nevertheless, as such it consists in the main of preservation

Fig. 2: A view of the excavation work carried out at the archaeological site of Barsinia, first season 2006.

Fig. 3: A photograph of some architectural remains uncovered at Barsinia site.

Fig. 4: The upper entrance of the tomb no.1, in which the glass bottle was found.

Fig. 5: The interior structure and environment of the tomb no. 1, where the glass bottle was uncovered.

with scarcely any emphasis upon elucidating the nature of the material, which is more loosely called cleaning. However, the recent applied studies performed by Sease (1984-1994) and Scott (2006) have affirmed that the several procedures of conservation on site used for all materials are: record keeping, handling, lifting, consolidating, cleaning, marking, joining, packing, transporting and storing. While the supplies used may vary slightly from material to material, the basic principles and procedures remain the same.

The aim of the present applied study is to establish an ideal strategy for glass conservation on site, especially the freshly uncovered glass that suffers different deterioration phenomena. It should be noticed that this study and its applications are based firstly on the previous studies mentioned above. On the other hand, some new procedures and applications have been created here to suit the nature of uncovered glass object and the environmental conditions, which make it a special case study.

Record keeping

When any conservation treatment is undertaken, whether in the field or in laboratory, it is imperative to make detailed and accurate records of every thing done to the object. To the archaeologist, the treatment applied may seem obvious, but it may not be so to the conservator in the laboratory who will eventually work on the object. Considerable time and effort on the part of the conservator, not to mention possible damage to the object, can be avoided if proper records are made in the field. Treatment reports need not be long or elaborate. Depending on the object and treatment, several lines or half a page in a notebook can be sufficient as long as all relevant information is provided. A treatment report should include a brief but clear description of the object, the material (s) of which it is made, and the condition in which it was found. Any weak areas, cracks, and the like that might not be readily visible should be indicated. It is always helpful to include sketches, if possible, photographs to indicate these weak areas and the position of cracks and missed parts (Sease 1994). Table 1 and Figure 6 demonstrate the context, geometric and artistic recording carried out on the four glass fragments, which make up the incomplete glass bottle excavated in the field.

Glass state

Inside the rock-cut tomb no.1, the mentioned glass bottle had been buried in a damp, semi cohesive, clay soil (Figs. 4 and 5). Under these conditions, the glass has been broken down. Furthermore, it has been subjected to very intensive chemical deterioration; the flux is leached out preferentially to the silica, and the corrosion process continues. It has been stated that damp soil attacks glass more than a dry one. Moreover, changes will resume as soon as an object is uncovered in the ground and is suddenly exposed to new environmental conditions. (Abd-Allah 2007) From the very moment the object is exposed to air, the process of deterioration begins again.

The mentioned glass bottle was found to be fragile and broken down into the four fragments described in Table 1. As soon as these fragments had been recovered, they appeared to be representing an incomplete bottle. A great area of its body is missing and small parts of the round base and neck are missed as well. Both the inner and outer surfaces of the glass are partially corroded and covered with thin, milky layers of corrosion products. Eventually these layers separate slightly and, being of different and irregular thickness, refract light differently, given a colored effect known as iridescence. The layers became extremely fragile and peel off in

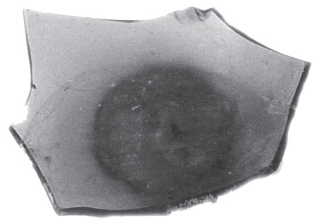
Piece	Square	Locus No.	Pail No.	Description	Dimensions (cm)	Photo
P. 1	Tomb 1 Grave 1	001	15	Round neck with waved rim decorated with wavy glass trails. Translucent glass with light green color.	Height = 7 Diameter of neck = 3 rim = 6	
P. 2	Tomb 1 Grave 1	001	15	Curved handle Opaque glass with dark green color.	Height = 8.5 Diameter = 0.7	
P. 3	Tomb 1 Grave 1	001	15	An irregular fragment from the body. Translucent glass with light green color.	Height = 5.5 Width = 2	
P. 4	Tomb 1 Grave 1	001	15	Round base with small part of the body above. Translucent glass with light green color.	Height = 1.2 Diameter = 2.6	

Table 1: The archaeological and geometrical documentation of the four fragments of the studied glass bottle.

very thin, onion skin-like pieces. Unfortunately, these glass pieces have been found to be covered with thick, hard layers of soiling and dirt, which strongly adhered to the glass surface. Moreover, the round neck has been filled with a hard lump of soiling and dirt (Figs. 7 and 8).

Treatment techniques

Lifting

Lifting refers to the process of removing objects from the ground. Generally, this is a straightforward process requiring the use of only common sense and patience. Sometimes, however, objects are too fragile and weak to be picked up unaided. These objects require the help of strengthening materials that either render the object rigid or encase it. The choice of a lifting method depends on the strength, size, weight, composition, and condition of the object to be lifted as well as on the soil conditions (Leigh

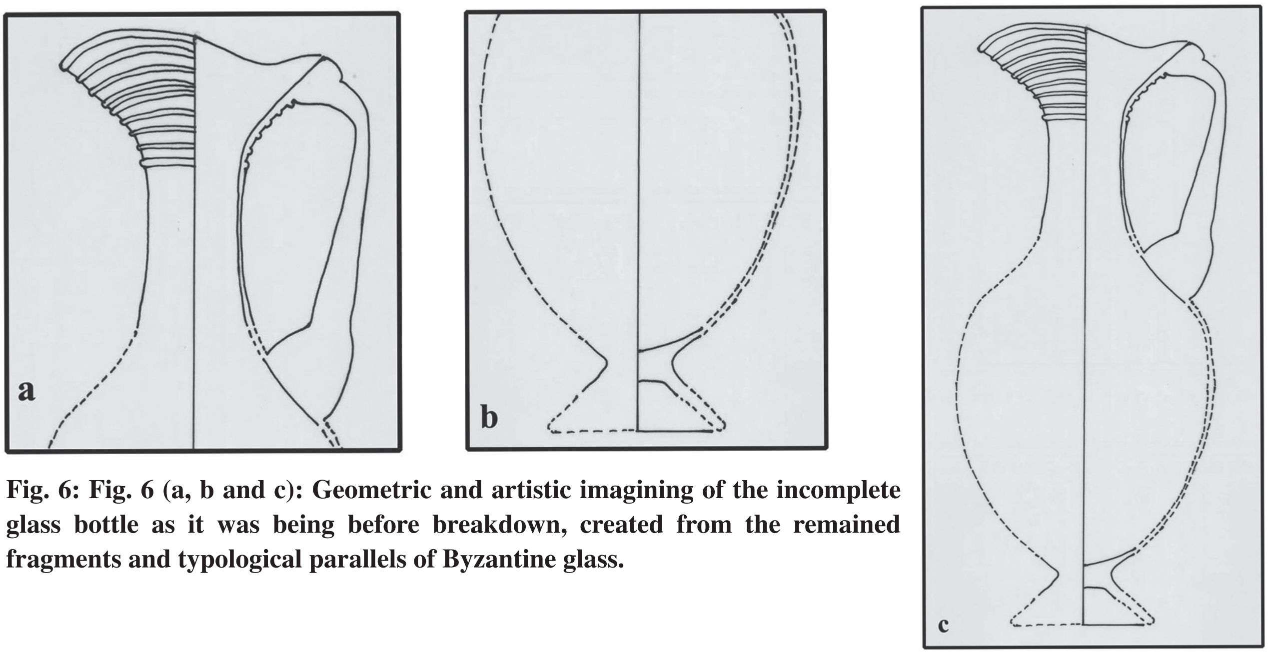


Fig. 6: Fig. 6 (a, b and c): Geometric and artistic imagining of the incomplete glass bottle as it was being before breakdown, created from the remained fragments and typological parallels of Byzantine glass.

1978, NPS 1993, and Scott 2006). All these factors were considered carefully when lifting the glass bottle.

As soon as the pieces of glass had appeared, they were recovered with the damp dirt again to avoid the rapid drying of the glass surface and prevent the glass from further damage. Then only a small area of each glass piece was partially uncovered to examine the glass surface to ascertain its conditions and applied decoration that has already become or will become detached from the glass object when it is lifted. Before lifting each glass piece, all dirt surrounding it was carefully removed that the piece sits on top of a pedestal of dirt, and its size and shape are fully determined.

Soft paintbrushes and wooden spatula are especially good for cleaning around glasses in the ground. As the metal tools and trowels can scratch and abrade the glass surfaces, they were excluded. Carefully, the iridescent layers not detached from the surface, some of the dirt

Fig. 7: The decayed glass bottle as it was uncovered before treatment; the glass surfaces are covered with thin, milky weathering crusts.

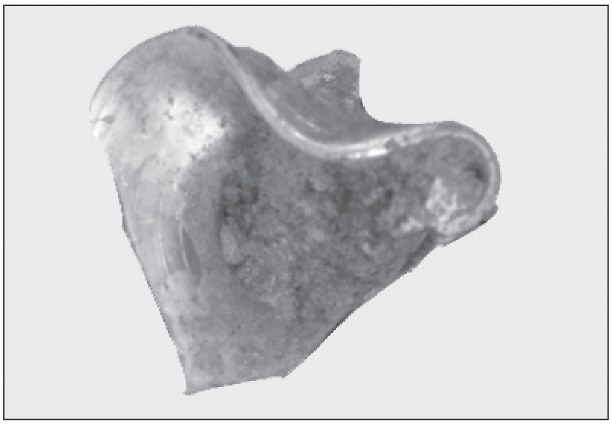


Fig. 8: The waved neck, inside which a hard lump of soiling and dirt strongly is adhered to the glass surface. Small parts of glass are missed.

adhering to the glass was left to protect these thin layers. Carefully the glass pieces had been undercut and, when becoming completely free, gently were picked up and placed in a rigid, padded container (Figs. 9 and 10). As the glass was found wet, it was kept wet and stored in a cool place away from direct sunlight until treating it in the field laboratory. During holding and transporting the object considerably, it was kept in a damp environment which closely resembles the one in which it was buried. To achieve this successfully, the glass pieces had been separated with a sheet of aluminum foil, and then the same soil matrix was used to cover them. It should be noted that, only the clean areas of glass, which were free from soiling but have iridescent surfaces, were consolidated initially to reaffix those iridescent layers to the underlying glass core beneath. A diluted emulsion of Polyvinyl acetate 3% and bandaging with gauze and plaster were applied for consolidating the fragments.

When glass deteriorates in the ground, it seems that it does not increase in volume and thus the original surface and dimensions of the glass will be represented by the outside of the weathering crust. It follows therefore that if the whole crust is removed, or if a part of thick crusts is removed in order to create a smooth patina, the dimensions of the artifact are irretrievable altered. Furthermore, it has recently been shown that useful archaeomertric data can be retrieved from the weathering crusts of enamels. Finally, even though the glass and removal of the crust in such a case could lead to complete destruction of the object (Newton 1989). However, cleaning of corroded or weathered glass is considered one of the most complicated problems; it is important to understand that cleaning means the removal of soiling (solid matter deposited during burial) and encrustation, which is detrimental to glass but not removal of any opaque weathering crust or a patina, which has a protective action and archaeological feature; this is destruction, for it is removing some of the original artifact (Caple 2000). Its removal means that the "original surface" of the glass is destroyed and the thickness of the piece, an important parameter technologically and for reconstruction, is altered. Removal will reveal a core of glass only where this remains and whilst it will be the original colour it will have an unsightly surface (Cronyn 1990 and Sease 1994).

In the present case, cleaning of soiling had been firstly carried out mechanically whilst the glass is still damp or wet. Encrustations are extremely difficult to deal with; if chemicals are

Fig. 9: Lifting the glass pieces from the ground using fine tools and soft brushes for removing the surrounding dirt.

Fig. 10: The glass pieces after removing the surrounding dirt. Hard lumps of dirt are isolated also with the surfaces.

used, they will attack any remaining glass and destroy the iridescent layers, whilst mechanical methods have been used with great skill. It is easy to detach the weathering crust where the encrustation is continuous with it. Nothing can be done to return the iridescence colour of weathered layers.

As the glass pieces and their soiling were damp; cleaning them need not involve the use of water. In fact, whenever possible, the use of water should be avoided to prevent further glass corrosion. To avoid any detaching of the glass surface, wooden spatula and soft paintbrushes were used to remove soiling and dirt deposited on the outer surfaces. In the case of hard lumps of dirt adhering to the interior surface of the round neck, no attempt was made to flick or pry them off because they can easily pull off some of the surface. Instead, they were touched with a brush containing acetone to soften the lumps enough for easy removal with a brush or wooden tool. However, the glass surfaces should not be moistened when doing this. Finally, cotton swabs containing acetone were used to control the cleaning process especially on the iridescent surfaces (Fig. 11).

Consolidation

Frequently, glass objects buried in the ground lose their adhesive constituents through leaching, ion exchange, or other chemical and physical processes. As long as they remain in the ground, the objects maintain their shape and bulk, but disintegrate if removal from the ground is attempted. Consolidation is the process by which these fragile materials are joined and strengthened by the addition of foreign substance that allows them to be lifted and handled safely. Consolidants must meet conservation requirements. It must have good adhesive and cohesive properties; achieve good penetration; be durable, stable, and reversible; and not alter the appearance of the glass being consolidated (Davison 1984, Horie 1987, Newton 1989, and Sease 1994). There was an urgent necessity to consolidate the glass pieces here for many reasons: first, the weathering crusts must be consolidated; second, these crusts (glass patina) must be reaffixed to any glass core remaining; and third, the iridescent layers will flake off unless consolidated.

As the glass pieces were damp; a diluted Polyvinyl acetate emulsion (PVA) was used to consolidate them. PVA emulsion is formed by suspending a resin/solvent solution in water, resulting in a liquid with a characteristic milky white color. Before an emulsion dries, it is soluble in water. It was confirmed that PVA is a stable consolidant resistant to yellowing and has a refractive index similar to glass (Smith 2003). Three concentrations of PVA were applied in three successive stages of consolidation: 2%, 3%, and 4%. Between each application, a few minutes of waiting were done. It is more effective to apply several thin coats of consolidant rather than a single heavy coat. A soft paintbrush was carefully used for applying the consolidant, and no damage was observed to either the glass surface or the iridescent layers. It should be noticed that the glass samples intended to be used for dating or other forms of analysis were kept without consolidation because the consolidant will contaminate the sample.

Joining

The joining of unweathered or lightly weathered glass is difficult because, being dense, the solvent from adhesive applied to the joins cannot escape through the glass. In addition, the faces of the breaks are very smooth, not allowing any keying of the adhesive, and furthermore there is no room for imprecise joins. The situation has been eased by the development of thermosetting resins, which can be used on glass in good condition, being removable, as they do not penetrate the fabric. If a resin with a refractive index similar to the glass being treated is chosen, the join will be invisible. In the case of weathered glass, it cannot be joined until it has been consolidated and then the adhesive must be compatible with the consolidant and the delicate crust. Good results in joining can be achieved only with considerable skill and use of the correct materials (Cronyn 1990 and Smith 2003).

However, joining was performed here only to the curved handle with the round neck (Figs. 12 and 13). Firstly, new super glue made of Cyanoacrylate had been used to piece the glass fragments together quickly, and then Araldite 2020 was used as a final adhesive; it was flowed into the cracks with a fine brush to permanently glue the pieces. Many experiments affirmed that Araldite 2020 is a good all-purpose, glass adhesive; it was specifically designed for glass bonding. Furthermore, it has several advantages: it is of low-viscosity, transparent, has a high mechanical durability, workable, resistant to discoloration, and has appropriate setting time (Gedye 1975 and Horie 1987).

Packing

The packing of archaeological glass, whether for storage or transport, is really a matter of common sense as long as a few important points are kept in mind. All packing materials should be selected with care. Although some materials may be readily available, they may not be suitable because they can cause considerable damage if they remain in contact with certain objects

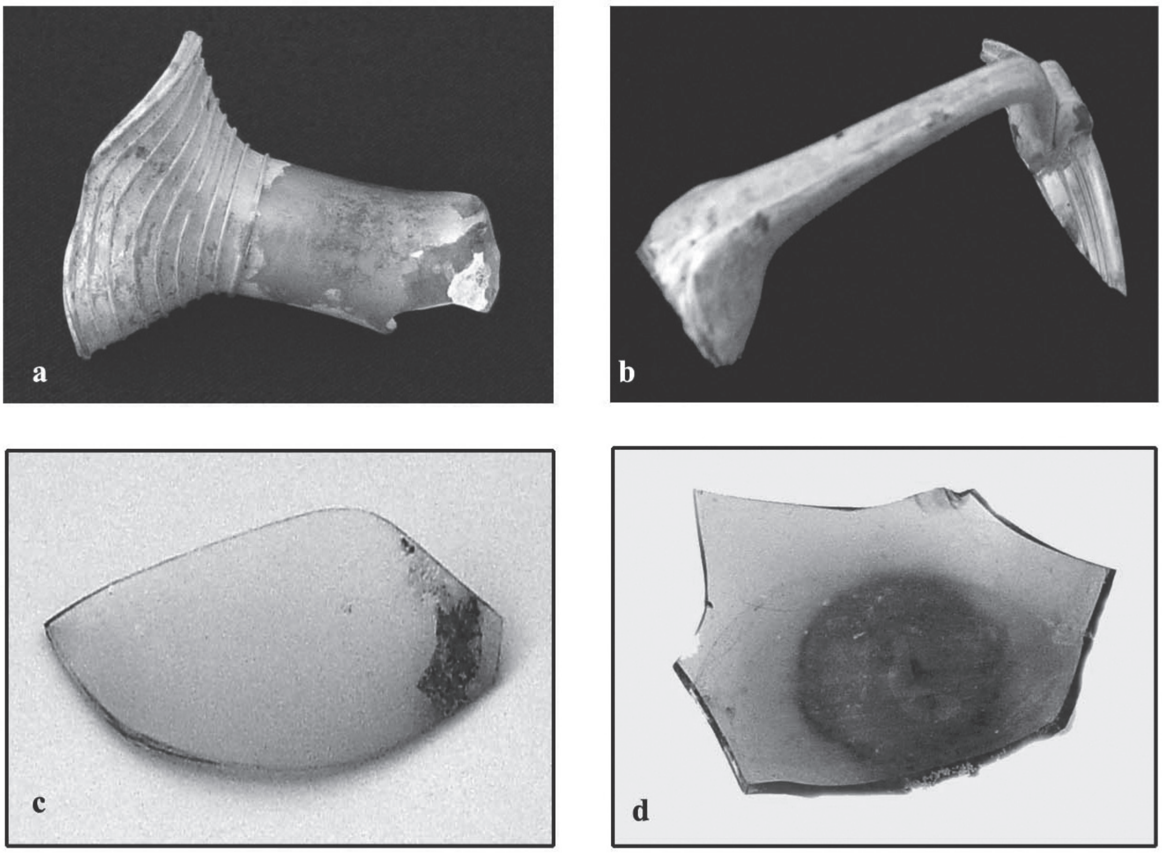


Fig. 11 a, b, c, and d: The glass pieces after the mechanical and chemical cleaning.

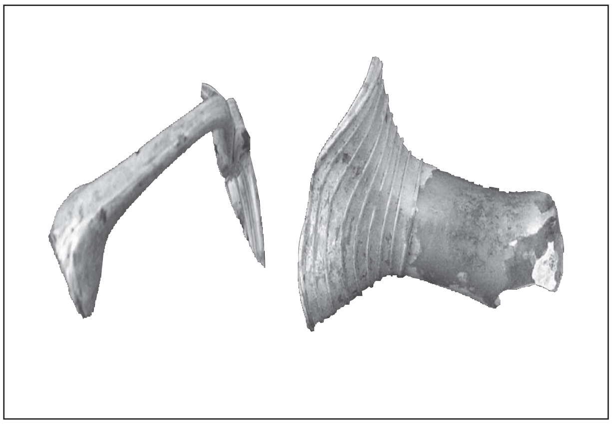


Fig. 12: The glass pieces (handle and neck) before joining.

Fig. 13: The handle and neck after joining.

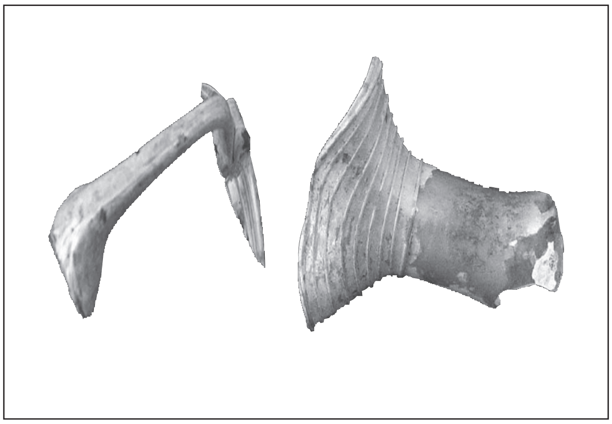


Fig. 14: Packing the glass pieces in a padded plastic food container with silica gel.

Fig. 15: A standard packing and storage system of fragile objects and pieces. (After Scott, 2006).

for long periods of time. Only inert materials such as acid-free tissue or polyethylene should come in direct contact with the object. Pieces of soft sponge or cotton can be very useful if pads of various sizes and shapes are needed to support objects when packing them. Such pads can easily be made by warping an appropriate amount of sponge or cotton in acid-free tissue or a piece of polyethylene and securing it with tape. When packing glass objects, a layer of moisture-absorbing silica gel should be placed at the bottom of the box before putting in the padding. Silica gel is an indispensable material for helping to keep moisture-sensitive material dry. To be best stored, most glass objects should be packed individually in well-padded, rigid container. Polystyrene boxes are ideal, as are plastic food containers with snap-on lids. The container should be large enough to accommodate the object comfortably and allow for adequate cushioning material. The glass object should never directly touch any internal surface of the container or any other object in that container (Singley 1981, Frank 1982, Crozo 1986 and Sease 1994).

Following the rules mentioned above, and according to the size and decay state of the glass bottle here, the glass pieces have been packed in a rigid plastic food container, which was well padded with cotton layers. In accordance with the shapes these pieces, they were padded and supported with additional wads of cotton. Empty spaces in the container were filled with crumbled rolls of cotton to prevent the pieces from moving. A layer of moisture-absorbing silica gel was placed in the bottom of the box before putting in the padding to prevent the glass from further corrosion Fig. 14.

Storage

Glass should be stored in as stable an environment as possible. Ideally, the relative humidity should be 40% or less (Scichilone 1995). Many pieces of glass are sensitive to moisture. Sodium and potassium are slightly soluble in some glass compositions. In the presence of high relative humidity, these components can be leached out to the surface of the glass where they are converted to carbonates. These carbonates attract moisture, and small droplets of water begin to appear on the surface of glass; hence, the name weeping glass. The leaching process causes tiny cracks to appear in the glass, and eventually the glass can be become opaque with small surface flaking. Further leaching and droplets formation will be stopped if the glass is kept at a relative humidity below 40%. If the storeroom is very damp, it may be necessary to pack glass in airtight container with silica gel. Furthermore, glass objects and pieces should be stored in suitable boxes or cardboard containers (Fig. 15). However, the glass pieces treated here were carefully packed and transported to the Faculty of Archaeology at Yarmouk University where they have been stored and further archaeological and chemical studies will be carried out.

Conclusions

Within the limits of this study, the following conclusions and rules are established:

Every material has stable form in relation to the environment in which it exists. In a burial environment, glass is very sensitive to physical and chemical processes and can be modified drastically when buried.

Changes will resume as soon as a glass object is uncovered in the ground and is suddenly exposed to new environmental conditions.

A qualified conservator who will assume responsibility for the conservation of archaeological objects must be present in the fieldwork. All personnel should be briefed on appropriate techniques for handling, packing, and storage of glass artifacts while in the field.

The field project should include a temporary laboratory, in which lifting, packing, and treatment materials and tools are available.

Wet or damp glass must be kept wet or damp prior to conservation. Glass found dry should be kept dry as well.

In the case of hard lumps of dirt adhering to the glass surface, no attempt should be carried out to flick or pry them off because such an attempt can easily pull off some of the surface and destroy the iridescent layers (glass patina)

Glass pieces to be used for dating or other forms of analysis should not be consolidated because consolidant will contaminate the samples.

In the case of weathered glass, it cannot be joined until it has been consolidated, a PVA emulsion diluted 1 to 4% with water should be used for consolidation especially of wet or damp glass objects.

Araldite 2020 is a good all-purpose glass adhesive whether in the fieldwork or in the restoration lab.

Dry pieces of glass should be packed in a rigid container which is well padded with cotton or polyethylene foam, and a layer of moisture-absorbing silica gel should be placed at the bottom of the container before putting in the padding to prevent the glass from further corrosion.

Glass should be stored in as stable an environment as possible. Ideally, the relative humidity should be 40% or less.

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ملخص: أثناء أعمال الحفائر الأثرية، التى قامت بها كلية الآثار والأنثروبولوجيا بجامعة اليرموك فى موقع برسينيا الأثري شمالي الأردن، فى موسمها الأول خلال شهري يوليو وأغسطس ٢٠٠٦، كُشف عن مجموعة قيمة من القطع الزجاجية، مختلفة الأشكال والأحجام والألوان، عُثر عليها مناطق متعددة بالموقع. وقد كان من أولويات العمل الميدانى في الموقع حفظ المكتشفات الأثرية التى يُعثر عليها خلال تواجدنا بالموقع على رأس فريق الصيانة والترميم، وصيانتها. ونظراً لما تمثله تلك المكتشفات الزجاجية من مدلولات أثرية وتكنولوجية وفنية، لها أهميتها فى التعريف بالموقع، وكشف العديد من الحقائق المتعلقة بتأريخة ودراسة مراحل الإستيطان فيه؛ لذا نالت تلك القطع الزجاجية قسطاً كبيراً من أعمال المعالجة والصيانة الميدانية. يستعرض البحث المنهج العلمى التطبيقى، الذي طُبق ميدانياً لمعالجة تلك القطع الزجاجية معالجة مبدئية، تهدف فى المقام الأول إلى الحفاظ على حالة الأثر، ومنع المزيد من التلف الفيزيائى والكيميائي، بدءاً من رفعة من التربة وتنظيفه وتقويته وإعادة بناءه، وصولاً إلى عملية نقله وتخزينه بالطرق العلمية المتوافقة وحالة الأثر إلى حين إستكمال عمليات المعالجة فى المعامل المتخصصة. وقد أختيرت إحدى القطع الزجاجية المهشمة والمتآكلة، التي عثر عليها، وكانت نموذجاً لمختلف المشكلات التى تواجه المرممين –غالباً – فى موقع الحفائر، كحالة دراسية تطبيقية جرت معالجتها بنجاح.

Note:

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