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STABILIZATION AND TREATMENT OF CORRODED GLASS OBJECTS DISPLAYED IN THE MUSEUM OF JORDANIAN HERITAGE/JORDAN

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ABSTRACT

A great collection of glass objects of different typology and colours has been displayed in the museum of Jordanian heritage, Yarmouk University in Jordan since 1988. Four glasses of this collection represent a special case; they appear to be the most decayed and completely corroded objects. As proved by EDX analysis, the multi corrosion layers were found to be completely decomposed. SEM examination shows the outer crusts seem to be inhomogeneous pitted, curviplanar, surface-planar and highly fractured forms. Furthermore, backscattered electron images revealed the inner surfaces appear to be altered and lose its glassy nature. The treatment strategy of these objects depends firstly on stabilizing the corrosion process and the expected devitrification chemically, through applying chemical inhibitors that have ability to arrest the continuity of corrosion reactions and prevent further damage of the original glass. Second, by consolidation of both the corroded layers and their underlying glass core, to stabilize them physically. A compatible preventive conservation plane that recommended for displaying the whole glass collection in the museum is established.

KEYWORDS: Glass corrosion, Examination and analysis, Active stabilization, Consolidation, Preventive conservation.

INTRODUCTION

The mentioned glass objects were delegated from the Department of Antiquities of Jordan, Irbid Archaeological Museum to the Museum of Jordanian Heritage in Yarmouk University in 1988. Since this date, they are displayed together in the ground floor of the later museum with other metal, stone and pottery objects in the hall no.3 inside the case no.3. Based on the stylistic and technological considerations, except the nursing glass no.A00 that dated to Roman/Byzantine period in Mesopotamia, the other three objects were attributed and dated to the Roman period (1st - 4th cent. AD). Archaeologists presume that they may be obtained from ruins of Tabaqat Fahl/*Pella*: the ancient Roman city in northern Jordan, which was a part of the region of Decapolise: a union of the Roman cities in Jordan. (Abd-Alla 2006). In June 2006, they were delivered to the Conservation Department of the same University where they seemed to me a good example of objects of completely corroded glass.

The aim of the present work was to operate a scientific technique for stabilizing the corrosion process and treating these corroded glasses with suitable mechanical and visual properties. Solving this task is the more important as there are many glass objects in the museums in danger of being lost through continuous corrosion and aging.

In the recent years, several studies on corroded glass are of chemical and treatment interests have been performed, on which the present study based and the following principles are established:

1. In the past, new conservation treatments were applied directly to archaeological material. This is now considered inappropriate, so a standardized testing procedure must be established. The treatment must not damage the object. The treatment must be reversible. The long-term effects are known (Faltermeier 1998).
2. The correct conservation treatment must be used to safely arrest the decay of the object and minimize any risk of damage to the object in application of the conservation treatment (Caple 2003).
3. In the case of corroded glass, it is important to understand that cleaning means the removal of soil or deposits and encrustation 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 original artifact. 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 and unintentionally remove evidence of the object’s past (Cronyn 1990 and Abd-Alla 2005).

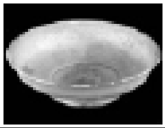
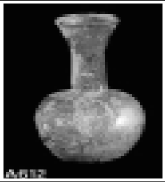
Museum	Pervious	Acquisition Source	Description	Photo
No A301	No J13669	Loan: Department of Antiquities of Jordan- Irbid Archaeological Museum.	Glass plate, ring base, blue green color. Roman period	
No A612	No 1599	Loan: Department of Antiquities of Jordan - Irbid Archaeological Museum.	Glass vase, oval body shape, concave base, polychrome color. Roman period	
No A613	No 1717	Loan: Department of Antiquities of Jordan- Irbid Archaeological Museum.	Glass vase, rounded body, high wide neck, concave base, polychrome color. Roman period	
No A00	—	Loan: Mr. Lutfi Al- Soumi collection - Syria.	A nursing bottle, rounded body with a side hole, high wide neck, concave base, polychrome color. Roman /Byzantine period.	

Table 1: The registration data of the glass objects.

Adapted from the Documentation Dept. of the Museum of Jordanian Heritage.

EXPERIMENTAL WORK

Optical examination

The preliminary examination by the critical eye and a magnifying hand lens (x10) indicate that these glasses are varied in their decay rate and corrosion nature. It seems likely that the weathering crusts found on the object no.A301 and A612 are an extreme form of the stone-like weathering, extremely hard and flinty. Whereas the surfaces of the objects no. A613 and A00 are covered by a thick opaque blackened enamel-like weathering surface, which in some areas has flaked away to reveal an iridescent layer beneath (a variegated coloration of the glass surface). The corroded surfaces had become very soft, powdery, and easy to destroy. Furthermore, the underlying glass core has become so weakened through deterioration that pieces are falling away. A trace of soil deposits and dirt were observed inside the hollow objects no. A612, A613, and A00. Furthermore, remains of weathering crusts, which flaked away from the interior surfaces also observed and collected for chemical analyses, microscopic examination and experimenting the materials and methods of treatment.

Microscopic examination

Some invaluable corrosion crusts flaked away and separated from the glass surfaces were collected and investigated by scanning electron microscopy (SEM model Quanta 200) in the Department of Earth Sciences, Yarouk University in Jordan. SEM was

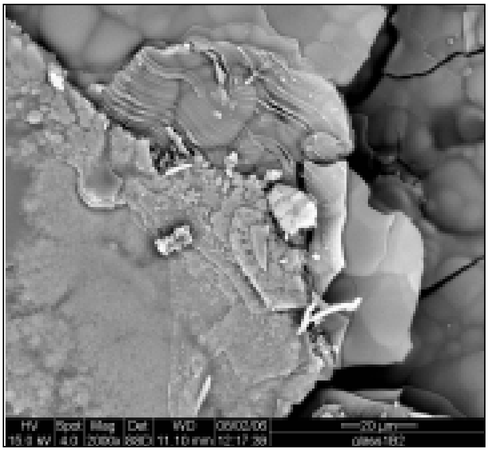


Fig. 1: A secondary electron image of a cross section through corroded crusts from the glass plate (A301) showing deterioration proceeding from the surface to the interior.

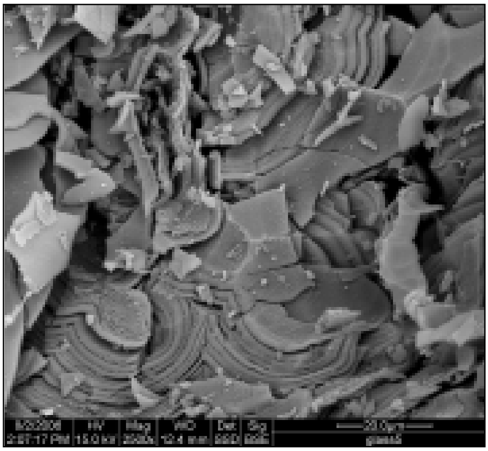


Fig. 2: A backscattered electron image of fragile crusts of glass bottle (A612) showing large areas of the weathering crusts be destroyed and rich in dissolution voids.

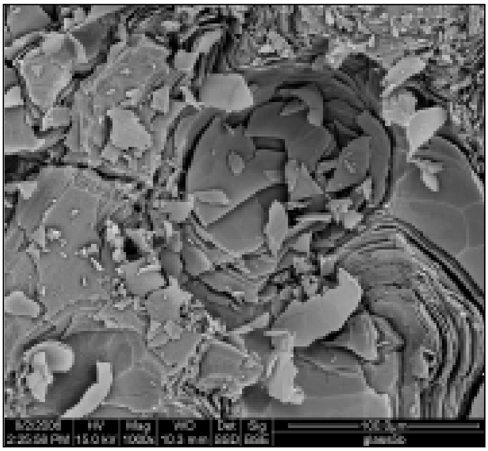


Fig. 3: A backscattered electron image of corroded crusts of glass bottle (A613) showing the weathered layers be destroyed, and losses its glassy nature.

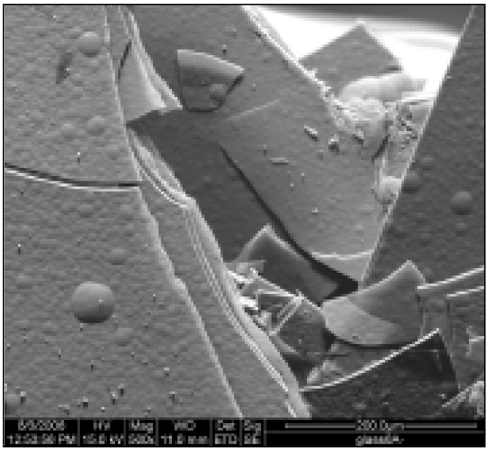


Fig. 4: A secondary electron image of a cross section through corroded crusts of the bottle (A00). The distinction between original glass, leached layer and surface crust cannot easily be made.

operated in both backscattered and secondary electron modes to examine both the compositional phases and the surface structure of the glass material. From SEM observation of the corroded glasses, it can be seen that all the glass surfaces seem to be inhomogeneous pitted, curviplanar, surface-planar and highly fractured forms. Large areas of the weathering crusts were destroyed and rich in dissolution voids and microcracks. Addition to that, other aspects of sugar-like surface, flaking, and highly fissured nature of decayed crusts were also observed. Figures 1 and 4 shows secondary electron images of magnified sections through corroded crusts from glass bottles no. A301 and A00, showing deterioration proceeding from the surface to the interior. In all that cases, no presence of crystals or devitrification was observed (Abd-Alla 2007).

EDX analysis

An energy dispersive X-ray instrument (model Philips XL30 with accelerating voltage 30 K.V) attached with the mentioned SEM system, was used for determination of the chemical composition of corroded glasses. Analyses results given in Table 2 indicate that these glasses identified as potash-lime-silica (K_2O-CaO-SiO_2) glass, and characterized by high potassium and magnesium content. This composition indicates also that they made with plant ash soda as a source of alkali. Furthermore, it is in agreement with the results of recent studies of Al-Ahmed and Al-Muheisen (1995), Brill (1999) and Abd-Alla (2006) about the chemical composition of the Roman and Byzantine glass in Jordan and Mesopotamia. Chemically, these glasses are completely decomposed due to attacking of the intensive deterioration factors especially water for long time in the ground, and due to the inappropriate displaying in the museum. There is an obvious change in the compositions of the outer weathering crusts in comparison with the interior glass cores underlying them, i.e., sodium and potassium content decreases (Na_2O avg. 2.59% and K_2O avg. 1.08%) and Silica content increases (SiO_2 avg. 78.29%).

METHODS OF TREATMENT

Cleaning

The glass surfaces of all the objects were very brittle and easy to flake off, and on the surfaces were found several cracks. In addition, no thick cores of original glass were found which excluded the use of mechanical methods to remove soil deposit and dirt. As the water and moisture are the most important factors initiating and sustaining forms of glass decomposition, even damage caused by dehydration is consequence of previous attack by water (Newton 1989), therefore wet cleaning using water also excluded; hence chemical cleaning using organic solvents had to be applied here. Cotton swabs saturated with acetone topically used for delicate cleaning work (Sease 1994). This cleaning method has two advantages: it does not damage the glass surface, and the visual appearance of surface iridescence not destroyed.

Sample No	Oxides (Wt. %)										Total %
	SiO_2	CaO	Na_2O	K_2O	Fe_2O_3	MgO	MnO	Al_2O_3	CuO	Cl_2O	
A 301	81.63	2.61	1.86	0.33	1.67	2.25	1.53	7.86	—	0.52	100
A 612	76.72	6.76	1.48	2.19	2.19	1.03	—	4.91	—	4.36	100
A 613	82.64	1.31	5.66	0.78	2.42	1.80	—	2.90	1.50	1.00	100
A 00	72.46	2.48	1.37	1.03	—	1.33	—	4.88	2.02	4.51	100

Table 2: The chemical compositions of weathering crusts of glass objects, obtained by EDX analysis.

Stabilization

According to the American Institute for Conservation of Historic and Artistic Works (AIC) definitions of conservation terminology, stabilization scientifically, means treatment procedures intended to maintain the integrity of cultural property and to minimize deterioration. Caple (2000) mentioned that stabilization is the act of preservation by causing the creation (or slowing to a minimum rate) of the decay process. This requires the identification of the cause of decay and its mitigation, which can be achieved through preventive or interventive conservation. Any stabilization treatment normally seeks to retain the object's present visual form. Decay and stabilization processes occur in three categories: biological, chemical and physical. Stabilization processes can be achieved through these categories as follows: biological, immobilize organisms by removing reaction agent (O_2, H_2O, heat, light); chemical, remove reaction agents (O_2, H_2O, heat, light, catalysts); and Physical, eliminate reaction agents (force, H_2O), consolidate, protect or support. However, the stabilization of the glass as of all materials falls into two main categories:

a. Active stabilization

This process means the treatment of glass to arrest decay and to stabilize them where possible. There are several aims involved in the active stabilization of weathered glass. First, water must be removed without the crust shrinking/ exfoliating/crumbling; second, the crust must be consolidated; third, it must be reaffixed to any glass core remaining; and fourth, where possible, transparency must be reintroduced. The last aim needs qualifying; where glass shows slight iridescence, this type of crust is said to be a patina giving beauty to the object. However, this process was carried out of the four glasses through the following tow procedures:

1- Chemical stabilization

The chemical stabilization were carried out of the four glasses through creating a chelation process using the chelating agent ethylendiaminetetraacetic acid (EDTA, $[(HOOCCH_2)_2NCH_2])$. According to several successful experiments had previously been carried out in similar cases, it is generally accepted as the most effective chelating agent recommended for cleaning encrustations on glass surface and acts chemically to inhibit or prevent further glass corrosion depending on its concentration and pH value. It was more effective at neutral pH with low concentrations around 5% - 10 %. (Paul 1978, Ernesberger 1978, Newton 1989, Calt and Spare 2004, and Abd-Alla 2005). A neutral solution of disodium salt of EDTA (pH 7) at 5% concentration was applied for all the glasses by brushing technique (the use of soft paintbrush). The aim of this treatment was to arrest the continuity of corrosion reactions and to prevent any expected devitrification to occur. This treatment successfully carried out, no damage of weathering crusts was observed and the visual appearance of iridescence not destroyed.

2- Physical stabilization

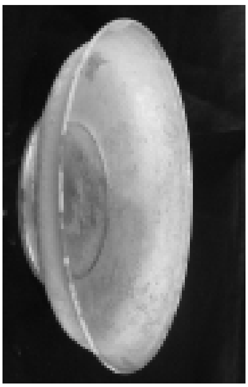
As the glass objects are completely corroded or decomposed and their surfaces are fragile and liable to crumble or flake upon drying or handling, therefore consolidation of these objects became necessary to undertaken. There are several aims involved in the consolidation process of these corroded glasses. First, to strengthen the underlying glass core; second, consolidate the weathering crusts; third, reaffixed the flaked layers to any glass core remaining beneath; and fourth, reintroduce transparency to thin weathering crusts where the glass shows slight iridescence.

Paraloid B-72 is an acrylic resin that is a good, all-purpose consolidant. It is a colorless, durable, stable resin with a T_g of 40ºC and a refractive index of 1.49 and, when applied properly, should not appreciably alter the appearance of the material to which it has been applied (Horie 1987, Newton 1989, Cronyn 1990 and Sease 1994). A diluted solution of paraloid B-72 3% dissolved in acetone has been applied by a fine spraying technique for each glass object, spraying is a very save technique and compatible for such fragile glasses. After 24 hours, they were reconsolidated using a concentrated solution of paraloid B-72 5% to emphasis the process of consolidation, and act as a coating film on the glass surface to protect it from the effect of environmental conditions, especially the effect of moisture and relative humidity that raises constantly in the museum all year long (Al-Ahmed and Khasawneh 2006).

b. Passive stabilization

Passive stabilization means the control of the surrounding environment to prevent further decay. The stabilization of the environment is often outside the area of a conservator's immediately responsibility. He should however be consulted as to suitable environment for antiquities, and should thus be in position to advise upon the correct conditions and methods of storage and display. The prevention of further damage and decay represents the minimum type of conservation, especially if the reversible techniques are not available at the time. Prevention of decay may only entail the remove of glass from an unsatisfactory environment (Newton 1989).

According to the research work performed by Al-Ahmed and Khasawneh (2006) to evaluate and study the environmental conditions in the museum of Jordanian heritage, they claimed that these conditions does not completely standard, and should be more controlled. Their measurements found that there are constant frequentations in temperature and


5. A301


6. A612


7. A613


8. A00

Figs. 5-8: The glass objects after treatment processes; the weathered crusts are stabilized chemically and physically, and the visual appearance of iridescence not altered or destroyed.

Figs.9 and 10: Showing the current displaying of the glass objects in the Museum of Jordanian Heritage (after treatment)

relative humidity (RH) throughout the year. However, all weathered glass can be stabilized simply by keeping it in a RH of about 40 per cent, above which the process of corrosion will be continue (Tomson 1987). On the other hand, we recommended that these glass objects and all glass collection in the museum should be displayed together in special displaying cases, and separated from the non-glass objects. In such state, the suitable environmental conditions required for preserving this glass collection can be controlled and standardized.

CONCLUSION

In the present work, a scientific approach for treating corroded glass objects displayed in the museum of Jordanian heritage was done. This extensive work not only describes the nature of conservation process but also provides an ethical framework to which the conservation of glass objects as divers as old materials. In addition, the implementation of conservation comprises the technical investigation, stabilization and conservation of glass objects. To be successful it depends on the conservator knowing: what the object is, where it comes from, the materials of which the object is composed, the decay mechanism of those materials and a variety of measures, which could be implemented to clean, stabilize and preserve the object.

However, conservation of completely corroded glass represents a complicated problem; many difficulties are facing glass conservators especially during cleaning weathered crusts and treating iridescent surfaces, as well as stabilizing corrosion reactions. This problem was solved here by carrying out the conservation process in a balance of three activities: investigation, all the forms of analysis and examination which uncover information about the object's composition, structure and damage state; revelation, cleaning and exposing the object, to reveal its original form and function; and preservation, the act of seeking to maintain the object in its present form, without any further deterioration. This typically involved a full range of preventive practices and the stabilization processes of interventive conservation.

In all treatment procedures of corroded glass objects, the visual appearance of weathered or iridescent surface (a protective layer or a patina) must not be altered. Stabilization can sometimes alter the visual form of an object (e.g. darkening of a surface when consolidated or destroying the visual appearance of iridescence during the chemical treatments). There is a balance to be struck between gaining a physically stable robust glass object and the change in visual appearance. It can often be helpful to combine a number of different approaches to successfully stabilize corroded glass objects: treating the glass object with chelating agent (EDTA), chemically, to deactivate the corrosion process; consolidation and coating of the decayed surface with acrylic resin (Paraloid B-72), physically, to strengthen the fragile crusts and protecting the weathered surface; and creating the approach of preventive conservation to improve the display system and preserve the object in a stable and appropriate conditions.

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COMMERICAL PRODUCTS AND SUPPLIERS

Paraloid B-72, Code: 112390, Canada colors and chemicals, 80 Scarsdale Road, Don Milles, Canda.

EDTA: (Disodium ethylendiaminetetraacetic acid) [Na_2 EDTA], Sigma, product No: 4884, Swiss Company for Chemicals, 106 Nile Street, Giza, Egypt.

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