Analysis and conservation of a weeping glass scarab

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Summary An Egyptian glass scarab (1891,0509.35: EA 22872), previously thought to be from the New Kingdom period, was found upon conservation to be weeping. Analysis of the glass showed it to be of an unstable composition with high soda and low lime concentrations. The composition is similar to rare items found in the tomb of Nesikhons dating to the Third Intermediate Period. The weeping salts were found to be predominantly sodium formate (methanoate) produced as a result of off gassing from the storage environment. The analysis and conservation of the scarab are described and recommendations made for future storage of the object.

INTRODUCTION

A blue glass scarab from ancient Egypt (British Museum 1891,0509.35: EA 22872; Figure 1) came into the collections of the British Museum in 1891, but its provenance is unrecorded. It was briefly mentioned by Budge [1], and was also recorded by Cooney as possibly New Kingdom and likely to have been intended as an inlay [2]. The object is not inscribed, although Cooney considered that the wings had been incised after moulding. He observed that the piece had broken into pieces and was in poor condition. The object was examined by the British Museum Research Laboratory in 1954 when Bimson recommended that, to prevent further deterioration, the object be kept in a desiccator over dried silica gel [3]. In spite of conservation in the intervening period, the condition of the scarab continued to deteriorate (Figure 2), as the glass is weeping, which is not usually seen in glass from ancient Egypt. This paper describes the conservation and analysis of the scarab, which has a similar composition to Third Intermediate Period glass from the tomb of the Nesikhons. The purpose of this contribution is to draw attention to the special significance of this scarab, and to urge curators and conservators to pay particular attention to other Egyptian glass artefacts that show evidence of ongoing deterioration in the museum environment.

Figure 1. Egyptian glass scarab 1891,0509.35 (EA 22872)
CONSERVATION

The scarab was transferred to the ceramics and glass conservation studio as it was found to be deteriorating in storage. Small splinters of glass had become detached and the object seemed generally to be in a fragile state. The scarab had been conserved before as it had broken previously and had then been assembled and bonded using an acetone-soluble adhesive (probably cellulose nitrate). It was not known, however, when this treatment was carried out, as no conservation records could be found for the object.

The adhesive had subsequently yellowed, some of the joins were misaligned and some appeared to be failing. Salt crystal growth was apparent on the object; especially in cracks and in gaps between joins. In addition, droplets of a slightly viscous, clear liquid were covering the surface, occasionally forming small pools, Figure 2.

The object was carefully cleaned with a mixture of distilled water and industrial methylated spirit (1:1 v/v), using cotton wool swabs. Although it would have been desirable to dismantle the object completely in order to remove the yellowed (and probably weakened) adhesive, to realign the fragments and to remove any corrosion products fully, it was decided not to attempt this, as it would have produced many fragments (a large number of which would have been tiny) in need of reattachment. It appeared that the object had suffered damage since the previous conservation treatment, as there were many unconsolidated cracks and fresh breakages. It is possible that the build up of pressure inside the object caused by the growth of salt crystals in cracks and fissures was responsible for this damage. Any attempt to reverse the previous restoration completely would have posed a considerable risk to the object and would most likely have resulted in further breakage and loss of position of fragments.

Only two old joins were dismantled using acetone (propanone) and these were then realigned and bonded with Paraloid B72. Fresh cracks and old bonds were consolidated as necessary, but this was done carefully and slowly to avoid softening the old bonds unduly and to keep any disturbance in the alignment of fragments to a minimum. Solutions with a variety of different concentrations of Paraloid B72 in acetone (applied by micropipette) were used. Finally, the detached chips were reattached as far as possible, also using Paraloid B72.

ANALYSIS

To elucidate the reason for the deterioration of the scarab, a small sample was examined in a scanning electron microscope (SEM) and an analysis obtained using the attached X-ray analyser, see the experimental appendix. Evidence of deterioration is clearly shown in the micrograph (Figure 3a), which shows a distinct de-alkalized or gel layer about 60μm thick on the surface (bottom right of image), and also the development of similar corroded layers along cracks which pass through the sample. The evidence of ongoing corrosion in the form of weeping on the surface of the object suggests that further deterioration along the cracks, resulting in the eventual disintegration of the scarab, would be inevitable if the object were not moved to a controlled storage environment. The polished glass sample was left in an ambient laboratory environment away from the object for two weeks and re-analysed in the SEM. Crystals had begun to form on the surface during this time (Figures 3b and 4), showing that the crystal formation was due to atmospheric pollutants rather than from previous repair materials. Weeping is a phenomenon in which alkalis from the glass are leached to the surface by moisture from the atmosphere and form salts that are themselves hygroscopic, attracting more water and promoting further corrosion [4]. A sample of the surface salt was analysed using ion chromatography.
ANALYSIS AND CONSERVATION OF A WEEPING GLASS SCARAB

Table 1. Composition of glass scarab EA 22872

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration / %</th>
</tr>
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<tbody>
<tr>
<td>SiO₂</td>
<td>68.2 ± 0.9</td>
</tr>
<tr>
<td>Na₂O</td>
<td>23.9 ± 0.8</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.8 ± 0.1</td>
</tr>
<tr>
<td>CaO</td>
<td>1.3 ± 0.1</td>
</tr>
<tr>
<td>MgO</td>
<td>0.8 ± 0.1</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.5 ± 0.1</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.2 ± 0.2</td>
</tr>
<tr>
<td>MnO₂</td>
<td>0.3 ± 0.1</td>
</tr>
<tr>
<td>CuO</td>
<td>2.0 ± 0.3</td>
</tr>
<tr>
<td>Sb₂O₅</td>
<td>n.f.</td>
</tr>
<tr>
<td>SO₃</td>
<td>1.3 ± 0.1</td>
</tr>
<tr>
<td>Cl</td>
<td>0.6 ± 0.2</td>
</tr>
</tbody>
</table>

Note: n.f. = sought but not found

(see the experimental appendix) and found to be a mixture of sodium formate (methanoate) and sodium acetate (ethanoate) in the ratio 2:1; no nitrate salts that might have been produced as a result of interaction with the probable use of a cellulose nitrate adhesive were present. The salts that were found have formed as a result of attack by organic acids (methanoic and ethanoic acids) that have off gassed from wood in the scarab’s storage environment.

The composition of the glass is presented in Table 1. In the context of New Kingdom glass, for which a large corpus of analyses is now available [5, 6], it is unparalleled in a number of respects. In particular, the lime content, at 1.3%, is significantly lower than that of New Kingdom glass, which is typically greater than 4%. The magnesia level (0.8%) is relatively low, with typical values in excess of 3%. The soda content of the glass, at 23.9%, is exceptionally high for Egyptian glass, as is the sulphate content at 1.3%, or more than double the values normally encountered in New Kingdom glasses [6]. The assignation of this object to the New Kingdom is therefore doubtful.

The compositional data immediately explain the tendency of the glass to corrode. The roles of lime and magnesia as stabilizers in glass are well known. However, levels of these oxides in excess of 5%, or other stabilizers such as iron oxide and alumina, are typically needed to prevent deterioration of a soda-silica glass. In the present case, the concentration of stabilizers in the glass is insufficient to inhibit corrosion and the glass spontaneously weeps in the museum store.

Although there is no obvious parallel in the composition of New Kingdom glasses, the authors are confident that the scarab is ancient, and not a nineteenth-century fake or copy, because of its chlorine and sulphate contents, which are characteristic of glasses made before the mid-nineteenth century from naturally occurring unprocessed sources of soda, such as Egyptian natron and plant ash. Furthermore, Schlick-Nolte and Werthmann have recently reported well-provenanced glass vessels with similar compositions from the exceptionally well-furnished tomb of Nesikhons, wife of the Theban high priest Pinodjem II [7]. Nesikhons died on 9 April 974 BC, so the vessels can be confidently dated to the tenth century BC. The analyses reported for these vessels give soda in the range 18.2–23.4%, lime 1.3–4.8% and magnesia 0.3–1.2%, very similar to the values for the scarab. Differences occur in some components such as alumina, typically 2% in the Nesikhons vessels, and chlorine and sulphur, which are significantly higher in the Nesikhons glasses. The analyses of the Nesikhons glasses were carried out using a standardless procedure that, in the authors’ experience, may well result in significant departures from...
the correct values for some components. It is significant that the analysis of New Kingdom glass from Timna in the same study shows levels of sulphur and chlorine that are significantly higher than in other analyses of New Kingdom glass [7], for example those published by Shortland and Eremin [6]. Hence, there may have been some unanticipated error in the analysis of these components in the Nesikhons vessels and their concentrations may in reality be closer to those of the scarab glass than appear to be. Even so, there is little doubt that relative to most ancient glass, the British Museum scarab and the Nesikhons glasses are of the same compositional type, suggesting that the scarab dates to around the same time as the Nesikhons glasses, and reflecting the use of similar raw materials and techniques to manufacture the glass.

The glasses of the scarab and the Nesikhons vessels are of particular interest because both appear to represent early uses of natron rather than plant ash as the primary glass flux, mixed with lime-poor sand or quartz [7]. In the early first millennium BC there was a move away from the use of plant ash soda as a flux towards natron, which eventually developed into the Graeco-Roman industry of the late first millennium. The origin of this trend, which is also apparent in some glasses found (although not necessarily made) in Mesopotamia [8], is of key importance in the history of glass technology, and is most likely to have begun in Egypt, where the natron sources were located. The scarab is likely, therefore, to represent another example of this early natron-based, low-lime glass from Egypt itself. It demonstrates that the use of the early natron-based glass is unlikely to have been restricted to vessels but was used for a range of glass objects. While this might demonstrate the existence of two workshops using the same type of glass, or the longevity of a single workshop, it is possible that the scarab entered the collections of the British Museum at the same time as one of the Nesikhons vessels, which had disintegrated by 1925, and was itself part of the same burial assemblage [7].

The identification of the British Museum scarab as a close relative of the Nesikhons group indicates the need for curators to be aware of the potential significance of unstable Egyptian glass, which may represent rare evidence of the early stages of the natron-based glass industry. Such glasses require storage under stable environmental conditions (ideally relative humidity 40 ± 2% and in a wood-free environment), or they are liable to disintegrate due to hydration corrosion along cracks in the body. Furthermore, every opportunity should be taken to investigate them by chemical analysis to extract the maximum possible information about their raw materials and the reasons for their decay.

EXPERIMENTAL APPENDIX

The sample for SEM analysis was mounted in epoxy resin, polished flat with diamond pastes down to 1 μm and coated with carbon. A JEOL JSM 840 SEM with an attached Oxford Instruments ISIS spectrometer with silicon lithium detector was used in this study. Operating conditions were 20 kV accelerating potential, 0.5 nA beam current and 100 second counting live time. Analysis quality was checked using Corning Museum standard glasses A and B.

To analyse the surface salts, a sample was taken and dissolved in deionized water. The solution was then analysed for common cations and anions using a Dionex DX600 ion chromatograph fitted with the following analytical columns: ICE-AS1 (1 mM heptafluorobutyric acid eluent) for HCO$_2^-$, CH$_3$CO$_2^-$ and CO$_3^{2-}$; AS14A (8 mM sodium carbonate / 1 mM sodium hydrogen carbonate eluent) for F$^-$, Cl$^-$, Br$^-$, NO$_2^-$, NO$_3^-$, PO$_4^{3-}$ and SO$_4^{2-}$; and CS12A (20 mM methanesulphonic acid eluent) for Li$^+$, Na$^+$, K$^+$, NH$_4^+$, Ca$^{2+}$ and Mg$^{2+}$.

MATERIALS AND SUPPLIERS

- Paraloid B72: Conservation Resources (UK) Ltd, Unit 2, Ashville Way, Off Watlington Road, Cowley, Oxford OX4 6TU, UK.
- VWR International Ltd, Hunter Boulevard, Magna Park, Lutterworth, Leicestershire LE17 4XN, UK.

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REFERENCES