

Ancient biographies: trace element analysis to investigate provenance and transportation mechanisms of Late Bronze Age glass

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Introduction

The theory and practice of both forensic science and archaeology are based on the same underlying principles: both disciplines use standard operating practices, developed over years of best practice, to collect, preserve and examine physical evidence to support scientific propositions, which in turn substantiate facts.

Forensic science and archaeology are correlative and often overlap, not only using similar methodologies but also employing the same analytical techniques which find practical applications in both modern crime investigations and ancient contexts. Although forensic science is concerned primarily with obtaining results for presentation in a court of law, archaeology also relies on the same incontestable recovery and analysis of evidence. The results obtained from archaeological analyses are considered to establish new hypotheses or support existing theories, which can significantly alter the understanding of historical events, cultures or a specific individual.

Fundamentally, the application of forensic science and archaeology is to examine associated objects to construct a factual narrative of events. This paper examines a glass scarab found in an undisturbed tomb dated to the early New Kingdom era. The trace element analysis undertaken on the scarab provides provenance data, contributing to the biography of the women in connection with a harem palace in Ancient Egypt.

The resource of grave goods

The provision of grave goods was fundamental in ancient Egyptian funerary practices, and protocol dictated that the deceased be interred with items they used in everyday life, in addition to amuletic objects that would protect the dead, allowing them to continue their existence in the afterlife (Piccione 1999, p841). Burials of the poor would include a few modest belongings, whereas the tombs of the elite would contain prestige items, such as gold jewellery and cosmetics. The quantity and quality of grave goods were directly determined by the material wealth and social importance of the individual, with most items specially made for an individual post-mortem.

When placed in the context of an extensive cemetery, patterns of social stratification can be identified and applied regarding the town, city and area. Jewellery specifically played a significant role in Egyptian life and death; ceremonial jewellery and amulets were purposefully manufactured for the deceased once they had died; these items were placed on the body, within the linen wrappings, as well as in the tomb. It is acknowledged that only a

fraction of funerary jewellery remains from the quantity initially produced in the Dynastic period (Aldred 1971, p14). In modern archaeology, grave goods are one of the most critical and common sources of evidence which allow both scientists and archaeologists to establish facts about the culture and society of a group, as well as evidence of the technological capabilities of the era.

The arid environment in Egypt has in many cases allowed both grave goods and human remains to remain remarkably preserved, however the frequent tomb robberies, both in antiquity and relatively recently, has meant that critical information about the Egyptian 'mortuary cult' has been lost or destroyed. Before Egyptology and archaeology employed standard operating procedures for recording and excavating, artefacts were removed from affluent burials and distributed between sponsors and museums, with few records made of the context. These pieces when removed from their original location immediately lose vital information, specifically the contextual meaning and evidential weight; many artefacts also sustain damage due to the clandestine manner of the removal. The discovery of the tomb of Tutankhamun in 1922 was a significant landmark because, for the first time, the relatively undisturbed tomb provided a complete picture of how a king of Egypt was buried. Tutankhamun was not a notable potentate in his lifetime, yet the find revealed the variety and wealth of grave goods that were afforded to a minor ruler. The opportunity enabled Howard Carter to make a meticulous survey of the burial, and the grave goods in context, as well as taking a photographic record over the eight years required to clear the tomb.

The excavators of a small, but significant Egyptian site, Medinet el-Ghurob, or Gurob, in the Southern Faiyum region of Northern Egypt, also employed a more structured approach to earlier excavations in 1918-1920. The work carried out by Brunton and Engelbach was more comprehensively documented than previous investigations, comprising of a plan of the area and town, descriptions of the excavated graves and tombs, as well as lists and diagrams of the items recovered. Most of the smaller or seemingly less valuable items were removed from site and archived in museum legacy collections. In conjunction with the archaeological reports and historical data, the application of more developed analytical techniques to ostensibly less prestigious artefacts from legacy collections can provide new information about domestic technological capability, foreign migration and the transport of luxury items. In the case of Gurob, specifically by foreign women of high status who were resident at the harem palace.

Foreign women in Egypt

Diplomatic marriages were customary in ancient Egypt and Tuthmosis III (1479-1425 BC), like other Kings of Egypt, entered into several unions with foreign women of high status to cement advantageous relations and political stability with other states (Shaw 2011b; Kemp 1989, p 293). A tomb discovered in 1916 by local villagers in Wadi Qurud (a remote valley southwest of the Valley of the Kings, near modern Luxor) which contained the remains of three women also provides contemporary archaeological evidence of three diplomatic marriages made by Tuthmosis III during his reign. Although the walls of the chamber were undecorated, hieroglyphs on the canopic jars and other grave goods revealed that the tomb was constructed for three 'Asiatic' women of high status, who were married to Tuthmosis III (Lilyquist, 2004, p47). The names of the women: "Manuwai", "Manhata" and "Maruta" were determined as being West Semitic in origin (Lilyquist 2004, p.333), although the tomb and its

grave goods provide the only tangible information on the archaeological record about the three women. It is not known precisely which country they were from, or if they were related. The coffins and remains of the women were in an extremely advanced stage of decomposition due to flood water entering the tomb; therefore, the bodies themselves could not be examined. The tomb was dated to approximately 1450 BC, during the joint reigns of Hatshepsut and Tuthmosis III, which predates the death of Tuthmosis III by approximately 25 years (Lilyquist 2004, p 333). Although considered to be lesser wives of Tuthmosis III, the tomb contained a quantity of glass grave goods including jewellery, bracelets, headdresses and vessels. This collection of royal grave goods is an example of early New Kingdom glass jewellery related to foreign women of high status, potentially from both Egypt and Mesopotamia. The tomb contained a lotiform chalice (Accession Number: 23.9, Metropolitan Museum of Art) bearing the name of Tuthmosis III, which is recognised as stylistically Egyptian (Lilyquist & Brill 1993, p.62). The goldwork was also considered to be primarily Egyptian, apart from the granulated gold beads (Lilyquist 2004, p185). Other pieces in the tomb, however, showed a strong influence from Mitanni design: A wig covering, comprising of gold rosettes, described as the 'Great Headdress' (Metropolitan Museum of Art, New York, Accession Number: 26.8.117), is attributed to Near Eastern technique and style. The gazelle diadem (Metropolitan Museum of Art, New York, Accession Number: 26.8.99) also shows strong foreign influence (Feucht 1999, p 385).

Lilyquist proposed that the most likely residence for the three foreign wives of Tuthmosis III would have been at the harem palace at Gurob. Gurob was recurrently inhabited from the pre-dynastic era (circa 3000 BC). However, it was during the 18th Dynasty that the site gained real significance, with a temple and a 'harem palace' being established during the reign of Tuthmosis III (Shaw, 2011b). Harems played an essential function in ancient Egypt: the palaces provided accommodation for female members of the royal family, including widows of former kings and lesser wives of the incumbent ruler (Kemp 1989, p288).

Archaeological excavations at Gurob

Flinders Petrie initiated work at Gurob between 1888-1890, but only preliminary excavations were achieved. The second season of excavations at Gurob was left in the hands of a volunteer, Hughes-Hughes while Petrie devoted his time to the nearby sites of Illahun and Kahun. Hughes-Hughes had little formal archaeology training or surveying experience, and few records of the excavation were completed. A brief plan of the area was drawn when Petrie returned at the end of the second season to finalise the work (Petrie 1891, p15). Currelly and Loat undertook subsequent excavations in 1904, and a brief investigation by Ludwig Borchardt was completed in 1905. Brunton and Engelbach initiated excavations in 1920 but noted that progress was impeded by the lack of records produced by the previous excavators, particularly when opening graves that had already been cleared (Brunton & Engelbach 1927, p 1).

The excavations undertaken by Brunton and Engelbach focused on the remains of the temple and surrounding cemeteries. The main cemetery contained individuals of lower or middle status and the burials were classified by era, ranging from the 0-1st dynasty to burials from the 19th dynasty (Brunton and Engelbach, 1927, fig. 1). Brunton and Engelbach also surveyed 500 New Kingdom shaft tombs belonging to officials and high-status individuals; this included the tomb of Pi-Ramessu who may have been the son of Seti I.

At the northernmost point of the main cemetery site, point Q, three tombs were discovered in an isolated group; Tombs 20, 26 and 27. The three undisturbed tombs were similar in construction and design, being brick lined with arched roofs and plastered walls (Brunton, G. Engelbach 1927, p10.). The excavators also commented that it was likely that the three tombs belonged to a family group. Tomb 27 was the largest of the three tombs and contained the remains of seven females and two children with associated grave goods. Although larger objects were recorded in situ by Brunton and Engelbach in a scaled plan (Brunton, G. Engelbach 1927, plate XX), the positions of the small objects were not recorded in the publication due to the displacement caused by the accidental collapse of the roof during excavations.

Evidence of Foreign Occupation at Gurob

Although there is evidence stating that large numbers of foreign women of high status were forcibly transported to Egypt following one of the first campaigns of Tuthmosis III, conclusive evidence for foreign occupation of high-ranking women specifically at Gurob during the reign of Tuthmosis III is limited. The seventh pylon from the temple at Karnak describes the capture and deportation of that the wives and children of the King of Qadesh, and of other Syrian leaders, by the King of Egypt, who were given as servants (Sethe 1907, p185) and subsequently disappear from the archaeological records. Other textual evidence comes from the Gurob Papyri, discovered by Petrie between 1889 and 1890; Papyrus UCL 32795 states that foreign wives were in residence at the palace in the Ramesside era. It was proposed that foreigners were resident on the site, most likely in connection with the harem (Petrie 1891, p16; Bard 1999, p361).

In the excavation records, Petrie claimed that there were 'light haired bodies' in the Gurob cemetery and noted the discovery of a custom, previously unseen in ancient Egypt; the burning and deposition of valuable possessions in pits, under the floor of a residence, none of which appeared to contain human remains. Petrie attributed this custom to foreign residents at Gurob (Petrie 1891, p 16), the find being comparable with documented Mesopotamian burial customs (Van De Mieroop 1997, p83; Cohen 2005, p16).

Brunton and Engelbach did not record the presence of canopic jars in any of the three tombs at Point Q, which indicates that the individuals were not mummified, despite being wealthy enough to afford a private tomb (Brunton & Engelbach 1927, p10). Mummification during the New Kingdom era was standard practice for Egyptian burials and had been adopted by non-royal individuals who could afford it (Ikram 2015, p65). However, few canopic jars were in evidence at the site, and most of the tombs at Gurob were regarded as "shaft tombs", suggesting that a simpler burial was the prevailing practice performed at Gurob. It is the notable lack of shabtis in tombs 20, 26 and 27 which is most significant; shabtis would be expected in an Egyptian burial regardless of status (Ikram, 2015, p129), and they are in evidence elsewhere in contemporaneous tombs about the site. Therefore, the evidence indicates elements associated with a foreign burial. Further studies investigating the extent of the presence of foreigners at Gurob, particularly Hittites and Mycenaeans, are currently ongoing (Hodgkinson 2017, p189). Current fieldwork also aims to establish more information about the Gurob site, including ascertaining a firm chronology of the site, undertaking further excavations of the 'industrial area' where kilns were identified, and cataloguing small finds following a series of illicit lootings in 2011-2012 (Shaw, 2011a, 2012).

The Grave Goods of Tomb 27, Gurob

Among the grave goods recovered from Tomb 27 were thirteen pottery vessels and a kohl pot, sixteen scaraboid beads (including one glass example, the subject of this paper), cosmetic tools and strings of stone and glass beads. Using evidence from the grave goods, Brunton and Engelbach dated all three burials to the reign of Amenhotep I but did caveat the date by noting that some of the pottery was usually attributed to the reign of Tuthmosis III, therefore giving a conservative date of 1525 - 1425 BC. The scarab is 15mm long by 11mm wide at its widest point; One side is domed, the other side is flat and without inscription (Figure 1). The domed side has two shallow inscribed lines representing the two front legs of the beetle, and a slight depression representing the mouth. In transmitted light, the scarab is translucent blue, with a green tinge. The drill hole can be seen running longitudinally, and was drilled from each end, meeting in the middle. Part of the original threading is present - a stiff thread, probably organic - that still survives extending 2mm from the thread hole.



Figure 1 - Scarab D.1921.39 Left in transmitted light and right in reflected light. The thread can be seen at the bottom and the inscribed legs at the top. The thread hole is seen in transmitted light and the black coating in both. The grid is 5mm squares.

A surface 'coating' was observed on the two ends of the scarab, particularly at the rear end. The coating appeared dark grey to black but was not present on the raised areas of the scarab or the flat surface on the back.

The scarab was not cleaned before the Environmental Scanning Electron Microscopy (ESEM) or the Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) analysis and care was taken to avoid patches of visible corrosion or coating for the analysis of the body area of the scarab. The purpose of the ESEM analysis was to produce elemental data from the surface of the glass body, thereby enabling the identification of any original coatings or evidence of decorative settings.

The research question required that LA-ICP-MS analysis was conducted to provide major element compositional data from below the surface of the scarab to identify the scarab as being made from a typical Late Bronze Age high magnesia, plant ash glass. LA-ICP-MS analysis also provided trace element compositional data to confirm the provenance of the scarab by identifying the concentrations of known trace elements which are incorporated during the glass making process and occur in discrete levels, thereby enabling discrimination between the regions of production (Shortland, Rogers and Eremin, 2007).

ESEM and LA-ICP-MS analysis was performed on the scarab; The results of both analyses are presented in Table 1. ESEM was performed using a Hitachi SU3500N, running at 20kV with a live time of 50s. Quantification was carried out with standard EDAX software. The scarab was ablated directly in the large sample chamber of a New Wave 213 laser attached to a Thermo Series II ICP-MS. The conditions for analysis are laid out by Giannini (Giannini, Freestone & Shortland, 2017).

Results

The LA-ICP-MS analysis of the glass body, showed significantly higher soda with magnesia and potash, confirming that the glass is consistent with the well-documented composition of Late Bronze Age, plant-ash glass (Turner, 1956a, 1956b; Henderson, 1985; Lilyquist *et al.*, 1993), and that the scarab was coloured with copper. The covariant trace element analysis of the scarab showed that it was relatively high in chromium, with an average of 17 ppm, and lower in lanthanum, zirconium and titanium, with an average of 1.6 ppm, 8.1 ppm and 288.8 ppm respectively (

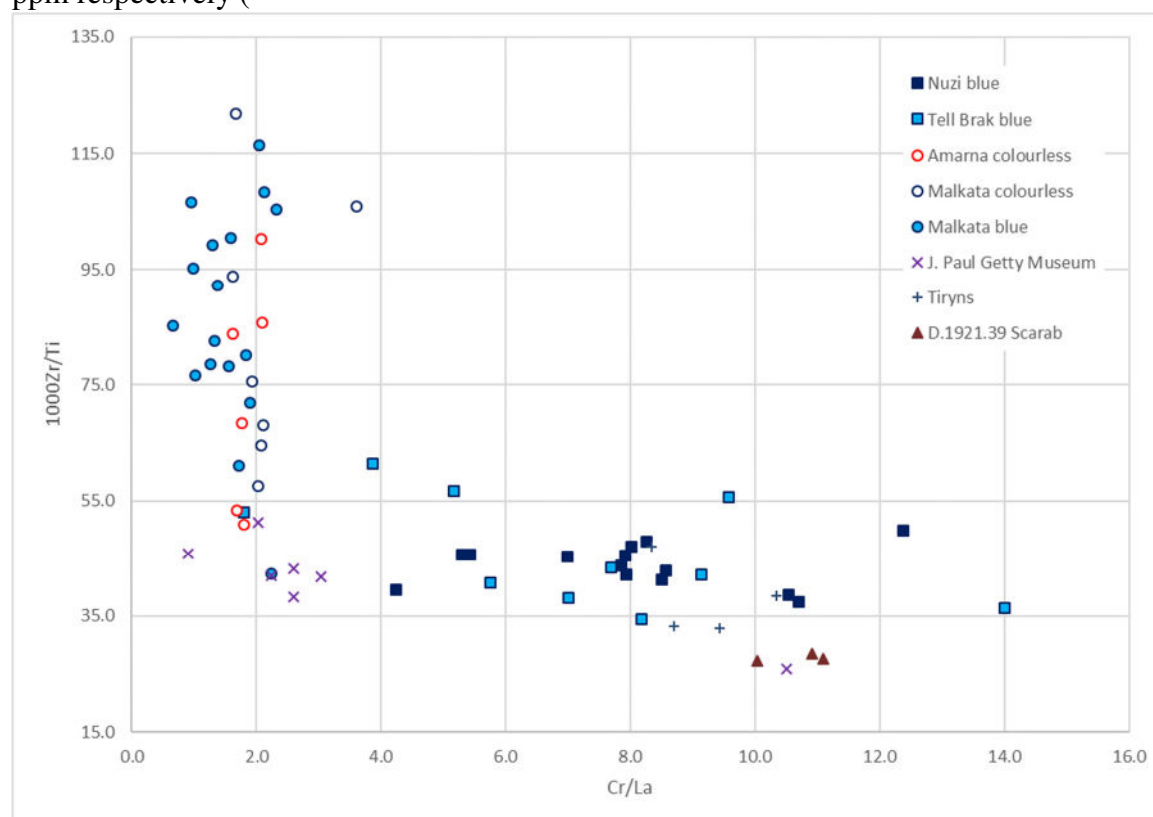
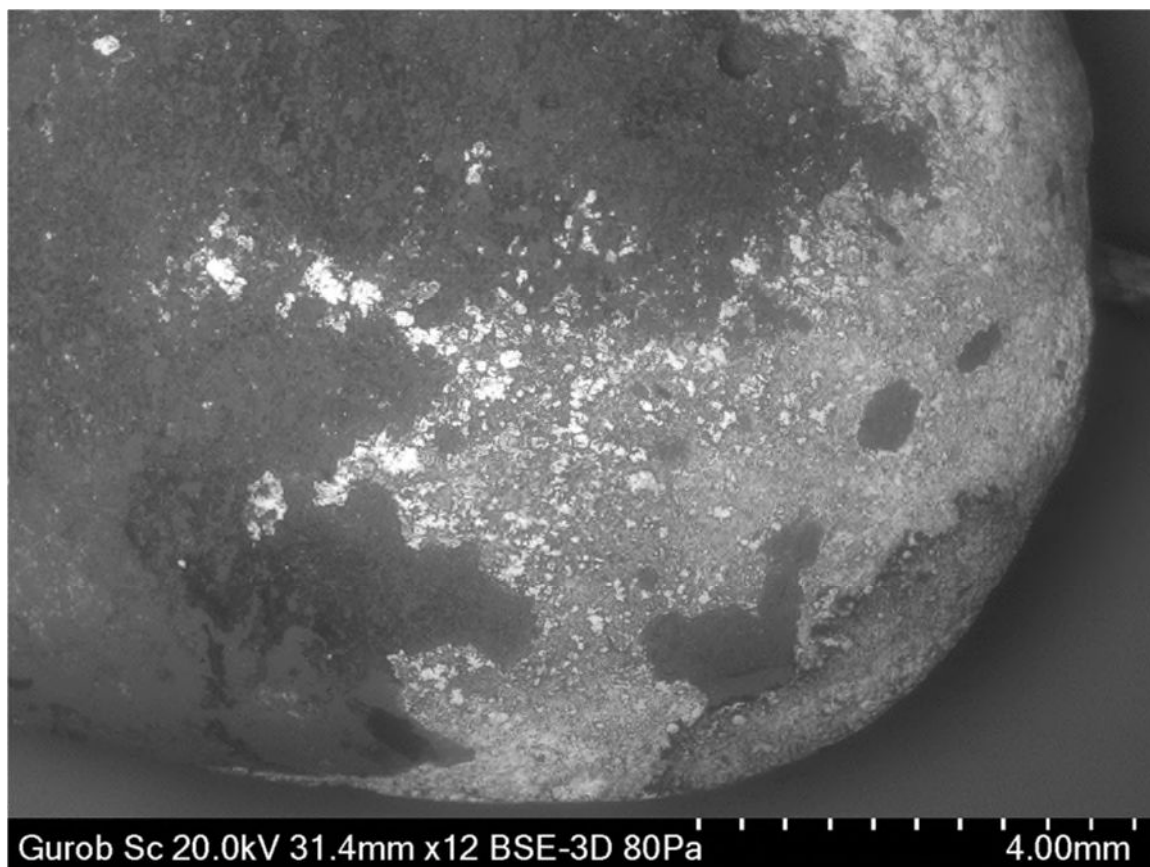


Figure 3). This signature is characteristic of glass made in Mesopotamia rather than Egypt, therefore it is very likely that the scarab represents imported glass from the Near East.

Conversely, glasses made in Egypt are characteristically higher in titanium, zirconium and lanthanum, but lower in chromium.

Egyptian blue glasses which are coloured with copper exhibit characteristically higher levels of lead, arsenic and tin (Smirniou et al. 2013) which is attributed to the use of bronze as a source of copper for the colourant (Kaczmarczyk et al. 1983; Freestone, 1991, p.43; Shortland et al. 2000). The expected level of tin present as an associated element in Egyptian copper coloured glasses is approximately 10% of the copper value. In contrast, the scarab analysed here had an average copper concentration of 7053.1 ppm, but contained only trace levels of lead, arsenic and tin; averaging 361.9 ppm, 43.9 ppm and 66.7 ppm respectively, indicating that a purer copper source was used, conforming with the characteristic colourant composition of Near Eastern glasses.

Images taken from the ESEM analysis (**Error! Reference source not found.**) showed that the dark coating, thought initially to be a weathering layer, appeared bright in the backscatter image; subsequent analysis showed that the coating contained silver with sulphur and chlorine. It is probable that the scarab was originally mounted in silver, and that the detected sulphides and chlorides are a result of corrosion.



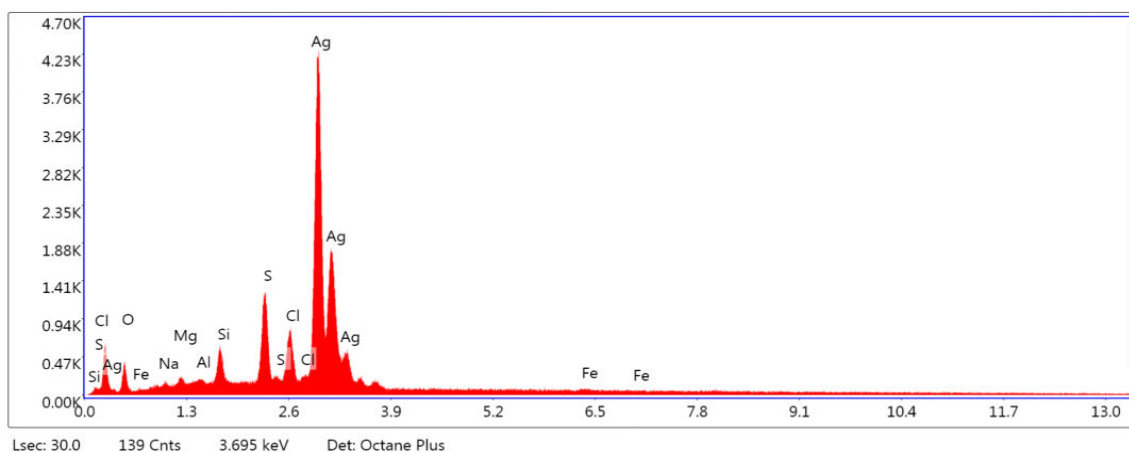


Figure 2 - SEM results for the scarab. The image, in backscattered electron mode, shows a bright partial layer on the glass, which the EDS spectra confirms is silver rich.

	ESEM-EDS				LA-ICP-MS	
Wt%						
Na₂O	5.0	4.0	5.4	13.9	12.5	14.9
MgO	4.3	4.4	4.1	2.6	2.5	2.5
Al₂O₃	2.7	2.8	2.6	0.7	0.7	0.6
SiO₂	64.3	69.7	61.9	73	75.6	73.2
P₂O₅	1.6	1.1	2	0.2	0.2	0.2
SO₃	2.7	2.2	3.1	-	-	-
Cl	2.9	2.6	3	-	-	-
AgO	3.8	1.9	4.6		see ppm	
K₂O	1.9	1.8	2.1	2.1	2.0	2.2
CaO	6.9	6.5	6.8	6.2	5.0	5.1
TiO₂	0.3	nd	0.5		see ppm	
Fe₂O₃	1.3	1.2	1.3	0.3	0.3	0.3
CuO	2.4	1.7	2.6	0.8	0.9	0.9
ppm						
Ti	-	-	-	295	285	285
Cr	-	-	-	17	16	17
Zr	-	-	-	9	8	8
Ag	-	-	-	5	10	6
Sn	-	-	-	65	68	66
La	-	-	-	1.6	1.6	1.6

Table 1 - Analyses of the scarab by ESEM-EDS and LA-ICP-MS

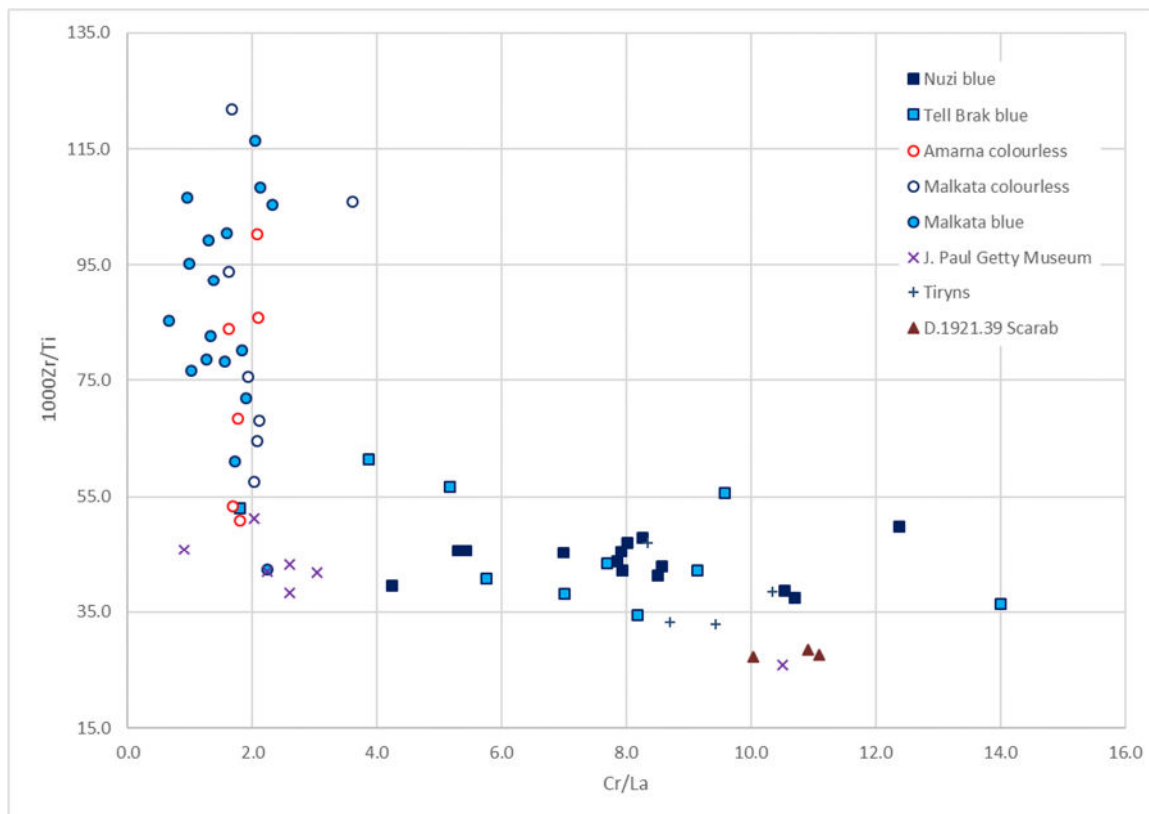


Figure 3 - 1000Zr/Ti ppm against Cr/La ppm of the D.1921.39 scarab compared with Egyptian and Mesopotamian blue and colourless glasses of known origin (Shortland, Rogers & Eremin, 2007; Walton *et al.*, 2009)

Compared with the LA-ICP-MS data, the ESEM analysis of the surface suggests lower soda and higher magnesia, alumina, iron and copper due to weathering of the glass. The relatively high levels of sulphur, chlorine and phosphorus on the surface can be attributed to corrosion caused by routine handling, or from contact with substances with a high salt content (Aldred 1971, p.33). The high silver level detected on the surface of the glass which appears uncoated suggests that a larger surface area of the scarab was covered in silver than is evident from the visible black coating.

Origin of glass and the transportation of luxury items by foreign women of high status.

By employing a multi-disciplinary approach to the investigation of the scarab and combining the analysis data with the burial context, this research establishes that Mesopotamian glass was being brought into Egypt possibly from the reign of Amenophis I by foreign women of the social elite. The results of the SEM and LA-ICP-MS analysis confirms that the scarab represents one of the first examples of Mesopotamian glass to be identified in Egypt; It is also the first confirmed Mesopotamian glass object to be presented in a typically Egyptian design. Because Near Eastern glass is generally poorly preserved when excavated domestically, well preserved examples which can be reliably dated to the early New Kingdom contributes to the knowledge of Mesopotamian glassmaking on the archaeological record, and thereby negating the preservation bias.

Further provenance analysis of glass objects from undisturbed, early New Kingdom tombs in Gurob would provide frequency data of foreign versus domestic glass from the earliest

known production era, hence providing supporting evidence for the original region of glass production. Supporting evidence for the original production site of glass is supported by textual, stylistic, compositional and technological evidence, the two primary candidates for the original production of glass being Egypt and Mesopotamia. The first significant amounts of glass on the archaeological record come from Egyptian tombs, specifically from Tuthmosis III's tomb and the tombs of the three foreign wives. However, the dating of the first glass vessel is complicated owing to the reburial of Tuthmosis I by his grandson, and it cannot be confirmed if the glass vessels were part of the original grave goods of Tuthmosis I (Shortland 2012, p.50). The glasses from the tomb of Tuthmosis III date to the later part of his reign, whereas the glass items from the tomb of the foreign wives contained pieces which were made approximately 25 years earlier.

The earliest datable glass was discovered in quantity at the site of Tell Atchana in the Levant; unequivocal archaeological evidence of glass making in Syro-Palestine to date is rare (Moorey, 1994, p.202; Shortland *et al.*, 2017). Further evidence of glassmaking and glassworking sites has been proposed by the discovery of glass debris or associated tools and kilns (Pusch & Rehren 2007; Nicholson 2007), particularly in Mesopotamia (Shortland, Rogers & Eremin, 2007; Shortland, 2012). Archaeological evidence of primary production of glass was only recently established in Amarna, Egypt (Smirniou & Rehren, 2011) and green glass rods, Mesopotamian in composition, were discovered as part of glass making debris (Varberg *et al.*, 2016). As discussed, early Mesopotamian glass is generally poorly preserved, and therefore the recovery of intact pieces is rare; It is also equally rare to find Mesopotamian glass in Egypt, and vice versa (Shortland 2012, p.49).

Stylistic and textual evidence has supported the supposition that glass first originated in Mesopotamia and was imported into Egypt initially as a direct result of the successful military campaigns of Tuthmosis III (Moorey, 1994). The Hall of Annals in Karnak depicts in detail what is believed to show the range of tributes extracted, or given as gifts, from vassal states, which include glass vessels and what has been interpreted as coloured raw glass ingots (Wreszinski 1923, p.50; Moorey 2001, p.9). The Amarna letters, cuneiform texts dating from between the reigns of Amenhotep III to Tutankhamun, record the orders for glass which were regularly requested by the King of Egypt from vassal states, Canaan and Amurru (Moran 1992, p.351-355). Evidence of other methods of transportation from Mesopotamia to Egypt has also been discussed, such as the capture or loaning of skilled workers, or artisans who were in the employ of the royal court (Moorey 2001, p.11). Studies undertaken by Shortland, Walton and Jackson and Nicholson have demonstrated the efficacy of using trace element analysis to distinguish between glasses made in Egypt and Mesopotamia. Geologically relevant trace elements incorporated into the glass during manufacture can be detected using LA-ICP-MS, thereby determining the origin of production and when placed in the context of the burial, the mechanism of migration of the glass objects themselves (Shortland, Rogers & Eremin, 2007; Walton *et al.*, 2009; Jackson & Nicholson, 2010).

Discussion

The proposed date of the tomb establishes the scarab as some of the earliest glass on the archaeological record and the first confirmed Mesopotamian glass found in Egypt. The scarab, in connection with the contextual burial at Gurob potentially establishes the importance of women in the transport of early glass from Mesopotamia to Egypt. The grave

goods from Tomb 27 contained several items of glass, gold and silver jewellery, which denotes that the women were of elevated status, or in the employ of a high ranking individual; jewels were customarily given to favoured servants and officials as a sign of the owners wealth (Aldred 1971, p.18).

The silver coating detected on the scarab suggests that the body may have been entirely coated in metallic silver, or more likely mounted in a bezel as other examples of this kind of setting were recovered from the site. Brunton and Engelbach also describe another scarab from Tomb 27 as having a silver mount. Silver was rare in Egypt, and there are few examples of it being used in the New Kingdom (Ogden 2000, p.170; Aldred 1971, p.33). Silver items were also found in the tomb of the Three Foreign Wives of Tuthmosis III (Lilyquist 2004, p.152), which draws another contemporary similarity with the tomb at Gurob. Silver coatings on glass are unusual in Egypt, with gold coatings being more common in Egypt and Mycenae. This use of glass is unknown, but most likely lies in the amuletic value of glass, evident from written sources, which detail in length the power of stones and glass to ward off evil and heal the body (Wilkinson 1971, p.7). The scarab, although characteristically Egyptian, was exported from Egypt in large quantities from the Twelfth Dynasty (1850-1795 BC) to the Levant and subsequently increased in popularity, being widely distributed from Canaan throughout the Mediterranean. In a non-Egyptian context, the scarab may not have inferred religious connotation, however the desire for foreign jewellery may have been a driving factor for the prevalent adoption (Reader, 2003, p.219).

Conclusion

The data obtained by LA-ICP-MS shows that the scarab is consistent with the known composition of standard Late Bronze Age plant ash glass. The scarab is coloured with a pure source of copper which is indicative of glasses from the Near East. The trace element analysis also indicates that the scarab is consistent with glasses of Mesopotamian origin. The date of the tomb, between Amenophis I (1525-1504 BC) and Tuthmosis III (1479-1425 BC), indicates that the scarab represents some of the earliest Mesopotamian glass to be identified in Egypt, and associated with foreign women of high status living at Gurob. The scarab also represents an early example of Mesopotamian glass being used to make amulets in the shape of a quintessentially Egyptian symbol. The ESEM analysis indicates that the scarab was coated or had been mounted in silver, which is unusual in Egyptian grave goods, suggesting a foreign influence.

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