Glass in African Archaeology: A new methodology offers new opportunities

The roots of the present collection of papers lie partly in the dramatic expansion of the analysis of archaeological glass that has occurred in the last twenty years or so, fuelled by the increasing availability of minimally invasive but precise and accurate techniques of chemical analysis (Rehren and Freestone 2015). In particular, laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS) allows the rapid analysis of small glass objects for around 60 chemical elements without the removal of a sample, leaving a small sub-millimetre scar which is unnoticeable under normal examination conditions. These not only provide a fingerprint which allows the glass to be sourced to its region of origin, but provide an understanding of its technology, which has undergone marked changes over time. The advances in our understanding of the technological context of glass and its development allow critical evaluation of the data and their interpretation, providing confidence in the conclusions and, in addition to being of interest in their own right, are crucial accompaniments to the provenance work.

Desirable, robust and exceptionally portable, glass beads provide an ideal material for the investigation of long-distance connections. However, many lack distinctive typologies so that recourse to chemical analysis is needed to determine their origin. The investigation of the bead trade through chemistry stretches back decades, notably through the application of neutron activation analysis (Davison and Clark 1974, Hancock *et al*. 1994, Hancock 2013) but the LA-ICP-MS technique, in particular as pioneered by Bernard Gratuze and further applied and developed by Laure Dussubieux and others (Dussubieux and Gratuze 2003, Lankton and Dussubieux 2006, Robertshaw et al. 2010, Wood et al. 2012) is without doubt the driver of current work. The glass vessels common in the archaeologies of the Middle East, Europe and the Mediterranean allow the removal of a discrete sample for analysis by cracking off the corner of a sherd, and have seen the application of a suite of elemental and isotopic analysis techniques to attain our current framework of understanding. However, the removal of equivalent samples from small spherical beads, as the most common form of glass in Sub-Saharan African archaeological context, is both challenging and overtly destructive. For many years our understanding of glass compositions around the Indian Ocean depended on a limited number of studies, in particular by Robert Brill of the Corning Museum of Glass (e.g. Brill 1987). Laser ablation is revolutionising the field.

The potential and limitations of the chemical analysis of glass beads are best understood through a consideration of the technology and production of glass which traditionally was prepared as a mixture of a limited number of constituents. The base glass, i.e. the uncoloured material, typically comprises two components: silica, SiO_2 which makes up between 50 and 80% of most archaeological glasses and which was obtained as quartz pebbles or sand, and a flux, which was added to lower the melting temperature of the glass and comprised soda (Na_2O), potash (K_2O), lime (CaO), less commonly lead oxide (PbO) or a mixture of more than one of these. The form in which the flux was added showed marked variations with place and time and its identification is the first step in the interpretation of the glass. For example, soda-lime-silica glasses may be divided into two fundamental categories, those where the soda and lime was derived from the ashes produced by burning plants, and those where the soda was obtained from mineral salts (naturally deposited by the evaporation of saline groundwater in semi-arid regions) and lime from the sand. They differ in concentrations of a number of signature oxides (of K, Mg and P) and are readily

distinguished; in bead studies they are given the prefix "v" for vegetal or "m" for mineral, hence v-Na-Ca for a plant ash-based soda-lime-silica glass. This type of categorisation allows the identification of glass produced under a specific technological tradition which operated over a wide region. A pertinent example is the soda-fluxed glass made in the Indian sub-continent, which was produced using a mineral soda and sand or soil (Gill 2017) and which differs from glass made further West by its low lime but high alumina. This m-Na-Al type is readily identified as traded over exceptionally long distances and has a wide distribution. It is not only found in African assemblages (Robertshaw *et al*. 2010, Wood *et al*. 2012; papers in the present volume) but as far afield as fifth to sixth century CE France (Pion and Gratuze 2016) and seventh to eighth century Scandinavia (Sode *et al*. 2017).

Unfortunately, the flux-based technological traditions frequently extended over broad regions for long periods. If a relatively precise chronological or geographical origin for the glass is required, we must look to the trace elements in the glass (those below about 0.1%) which were typically derived from the sand. Several sub-categories of m-Na-Al glass may be distinguished in this way, in particular by using the concentrations of the trace elements uranium and barium. While the conclusion that these represented different production locations with differing chronologies is robust, pin-pointing the actual production locations is much more problematic without the excavation of production debris for comparison, and for most of these types will require a great deal more work.

Turning to dating, there are a number of well-understood chronological changes in glass compositions which can be dated to within centuries or, for more recent material, within decades. Changes between the use of plant ash- and mineral-based soda in the Mediterranean are probably the best studied of these (Phelps et al 2016, Schibille et al. 2019, Shortland et al. 2006) but similar changes occur in base glass compositions in Asia (see for example Table 1 of Rødland, this volume). Also important are the changes in the use of the materials used to colour and opacify the glass. Cobalt, which generates a desirable deep blue colour, appears to have been obtained from a small number of locations over thousands of years and changes in source appear to have been relatively abrupt, resulting in marked change to the associated trace element profiles related to time and place (Gratuze 2013, Gratuze *et al*. 2018). The growth in experimentation and the understanding of chemistry from the fifteenth century onwards has resulted in a large number of potentially useful chronological markers in terms of both base glass composition (e.g. Dungworth 2012) and additives (e.g. Hancock 2013), which allow an increasingly refined compositional framework to be applied to the European colonial period.

Interpretation of bead assemblages through the approaches outlined can be constrained by several factors. The production of the glass material and the fabrication of the object can be widely separated, unlike the situation for traditional pottery production where raw materials and artefact production were closely co-located. In the first millennium CE, chunks of raw glass from the eastern Mediterranean were traded from the eastern Mediterranean to be shaped into vessels in western Europe. Glass artefacts can be re-melted and recycled. Beads themselves can be treated as a raw material to be broken up and re-melted to produce new objects which are more appropriate to the local culture. An example is the "garden roller" beads in southern Africa, which were made from crushed south Asian m-Na-Al glass (Wood 2016). Indeed, the evidence from Africa has the potential to provide important insights into the response of people to a new material and its technology. The recognition

that glass was being made from a unique combination of raw materials in Ile-Ife, Nigeria in the eleventh to fifteenth centuries CE and that the technology may have developed in a largely autonomous fashion (Lankton *et al*. 2006, Freestone 2006) may offer clues to the types of process that occurred during the spread of glassmaking in the Iron Ages of the Near East and China due to the much more comprehensive and detailed evidence base which is being constructed for the West African materials (see for example, Ige 2012, Babalola *et al*. 2017, 2018).

The present group of papers provides a snapshot of the investigation of African beads at an exciting time and provides a series of excellent examples of the state of the art. Dussubieux et al (paper 1) provide the first LA-ICP-MS study of beads from Malawi. They identify an early m-Na-Al bead originating in South Asia as well as European beads dating to the eighteenth and nineteenth centuries, and use a detailed understanding of changes in glass technology in this period to provide dating constraints. Lababibi et al (paper 2) provide a detailed discussion of the technologies of glassmaking and fabrication of bikini beads from Bida, Nupe land, based upon ethnographic evidence and a re-enactment of the process. They note the role of recycled glass and its effect of the compositional structure of the beads. The insights provided may in due course allow an understanding of the relationship between Ile-Ife glassmaking and that of Bikini glass, which in turn may shed light on the processes of technological transfer of glass technology in earlier periods within Sub-Saharan Africa.

Marín-Aguilera and Dussubieux (paper 3) discuss compositional and social aspects of the beads of the Shay peoples of Ethiopia. They use LA-ICP-MS to identify four compositional categories of imported soda-rich glass and further use trace elements to assign the origins of the glasses to the Middle East, Egypt, Palestine and to two regions in India. Rødland (paper 4) discusses an exceptionally rich assemblage of beads from Mkokotoni, northwestern Zanzibar, accompanied by evidence for a bead production workshop. The majority of beads from the site are in forms unparalleled outside the region, strongly suggesting local production. In this case LA-ICP-MS analysis, which has not yet been done, can be expected to provide key insights into the production process and the origins of the glass. Then-Obłuska and Dussubieux (paper 5) provide an overview of their work on glass beads from Lower Nubia spanning a period of some three millennia. Six glass types are identified and attributed to their regions of production; furthermore data are presented supporting local bead making in the area in late antiquity. In their investigation of beads from the fourteenth to fifteenth site of Songo Mnara, Tanzania, Wood et al (paper 6) identify a wide range of bead sources. They present evidence for imported Chinese beads and for the re-melting of imported glass beads to produce new forms at the site.

What is to be concluded from this excellent set of articles on archaeological glass in Africa? First, that there is now an established methodology, based upon LA-ICP-MS analysis and supported by a substantial existing body of analyses, which allows the robust, non-invasive provenance investigation of glass beads. The approach can also make significant contributions to chronology. More specifically, complex networks of trade and connectivity are being revealed which would have been less amenable to analysis using other categories of archaeological material; a new perspective is being uncovered. Of interest is the increasing evidence of local agency, in terms of the creation of new forms by the re-melting of imported beads and, in Nigeria, the manufacture of raw glass. Many questions could be asked here around the issues of innovation and technological transfer. What is clear is that, given the

vast area of the continent and the limited coverage so far achieved, we have a lot more to learn about African glass. The editors and authors are to be congratulated on this welcome, timely and most interesting collection.

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