ABSTRACTS

Conference cum Workshop on History, Science & Technology of Ancient Indian Glass

21-25 January 2019

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Indian Institute of Technology Gandhinagar
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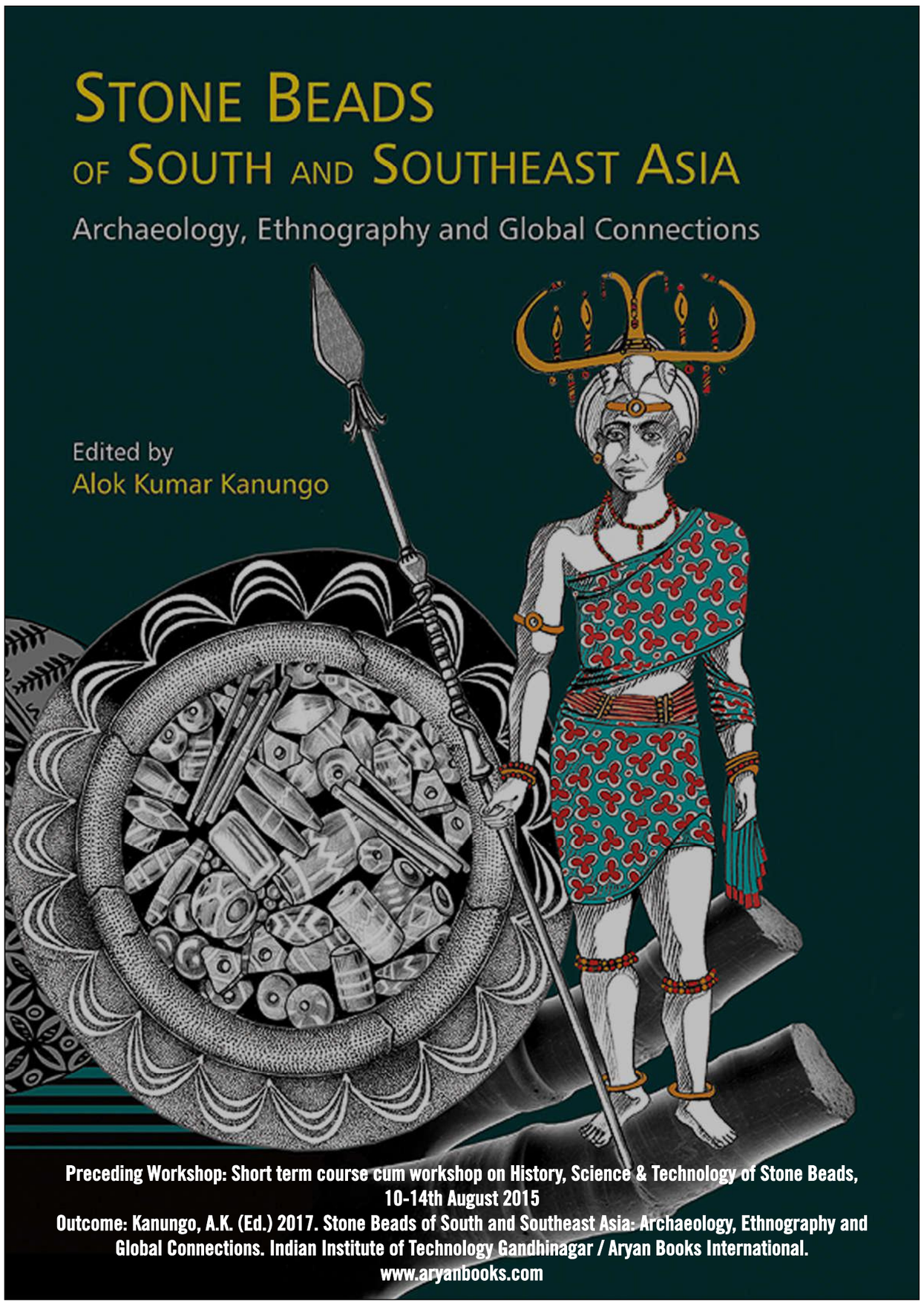

Preceding Workshop: Short term course cum workshop on History, Science & Technology of Stone Beads, 10-14th August 2015

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GLASS IN GENERAL

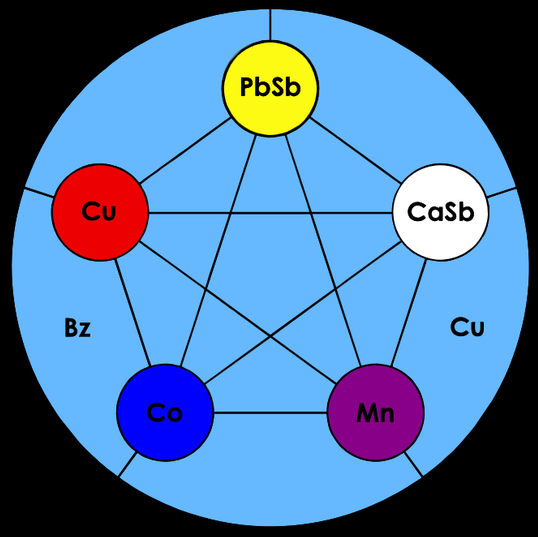
The Origin of Glass: the First Glass Industries in Egypt and Mesopotamia

Thilo Rehren, STARC, The Cyprus Institute, Cyprus

Glass is peculiar among the artificial materials of antiquity, in that it may well have been invented only once, before spreading through Eurasia and Africa. Initially designed to imitate precious stones it developed quite differently in different regions of the world, with jewellery and decorative items being fashioned from glass almost everywhere, but blown hollow vessels being restricted to a core western Eurasian and northern African region, and only emerging towards the end of the first half of the history of glass use.

This talk concentrates on the first phase of glass making, covering the Late Bronze Age plant-ash based production of glass in Egypt and Mesopotamia. Throughout this half a millennium glass retained its elite character and a well-defined palette of colours and working methods. As an elite industry it appeared well-controlled, although the notion of a palace-bound industry is probably no longer tenable in a strict sense.

At present, almost all our evidence for the glass industry comes from Egypt, with very little if any workshop remains known from Mesopotamia. So far, we see an industry consisting of several coexisting production sites specialising in just a few colours, and closely related artistic studios working the glass into mono- and polychrome objects. For the latter, they relied on a long-distance network of elite material exchange, bringing a wide range of colours to all studios.



The first phase of glass making comes to an end around 1000 BCE, with a combination of societal and technical changes contributing to the apparent near-disappearance of glass from the archaeological record for several centuries.

Elemental Compositions and Glass Recipes

Laure Dussubieux, Field Museum, USA

Glass composition has become a key tool for the study of ancient glass. This approach consists in measuring the concentrations of the different elements present in the glass. Information are then used to identify glass types and glass recipes to infer glass technology, provenance, circulation and sometimes, relative dating. If decades ago only the major and the minor elements (the most abundant elements) were determined, nowadays, trace elements (elements present in very small concentrations) are also accessible. With the full glass composition it is possible not only to distinguish different recipes but also to identify the use of different raw material sources among workshops sharing same recipes.

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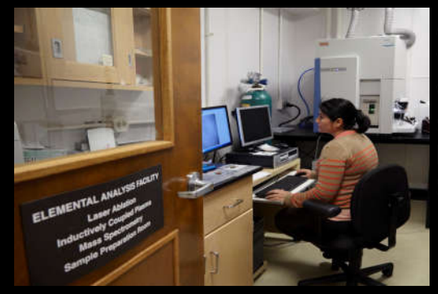


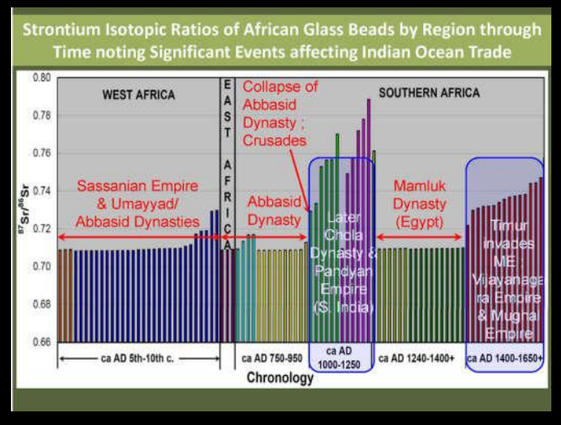
Although we will paint a quick picture of the different glass types identified through elemental analysis before the Modern Period in the Old World, we will focus more attention on the recent advances related to the mineral soda glass found between the 8th c. BCE and 8th c. CE around the Mediterranean region and to the mineral soda – high alumina glass found in South Asia.

The Isotopic Analysis of Ancient Glass

Thomas R. Fenn, University of Oklahoma, USA

Recent advances both in analytical techniques used to examine archaeological materials and in our understanding of various isotopes systems have led to an efflorescence of research applying isotopic analyses to examining questions of provenance in ancient glass materials. While initial applications of isotopic studies to ancient glasses began with lead isotope work by Robert Brill and colleagues in the late 1960s, advances in precision and accuracy, and, more importantly, the sensitivity of more recent instrumentation have opened up whole new isotopic systems for exploration.

The development of ancient glass research in the isotope systems of strontium in the early 2000s and neodymium in the later 2000s, have led to many new and exciting provenance interpretations. Furthermore, these encouraging results have been followed by more extensive exploration of the applicability of other isotope systems, such as oxygen, antimony, boron, copper, and more, to ancient glass research. The work with these new isotope systems also have led to large-scale characterization of raw material resources used in ancient glass production. As analytical techniques and instrumentation continue to improve, expect an ever-expanding use of existing and new isotope systems within ancient glass research.



Furthermore, these technological advancements will also lead to improvements in the quality of data generated, in reduced sample size needed, and in faster through-put. The following paper will summarize many of these exciting advancements of isotopic analyses in ancient glass research and speak to the potential for future work.

Glass in the Middle-East and Western Europe at the end of the first millennium CE, Transition from Natron to Plant Ash Soda or Forest Glasses

Bernard Gratuze, French National Center for Scientific Research

The production of natron glass which started at the beginning of the 1st millennium BCE was the prevailing one in the Mediterranean world for almost two thousand years. Depending on the Near Eastern regions (Syria, Egypt), its production seems to cease progressively from the end of the 8th century CE onwards.

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From that period, the production of glass from soda plant ash, which has never stopped, although marginal and restricted to some inland areas such as Mesopotamia, progressively replaced that of natron glass.

Studies carried out on glass from the Levant have shown that the late 8th century CE is the last period in which natron glass is present in significant quantities and the first where soda plant ash glass appears systematically (Henderson 2013, Phelps 2018). However, for Egypt, exactly when and how these transformations of the glass industry took place has long been unsolved. A recent study of Islamic glass weights and stamps, which provide a continuous chronology of glass compositions from the reign of Abd al-Malik (685-705 CE) to the reign of the Fatimid caliph al-Hakim (996-1020 CE), shows that glassmaking in Egypt developed at a different rate and independently from glassmaking centres in Syria-Palestine. It gives evidence that natron glass was at least produced in Egypt until the end of the 9th century (Schibille et al. submitted).

Thus, in the Mediterranean world a radical change is observed in glass production recipes between the end of the 8th century and the 10th century CE resulting in the systematic use of soda plant ashes instead of natron. This recipe will be adopted all around the Mediterranean and becomes the predominant one in that area before the end of the 12th century.

In Western Europe, the decrease of the import of natron glass at the end of the 8th century also induced a period of transition resulting in the emergence of the production of new glass types. Here, Near Eastern imported natron glass is progressively replaced by locally made glasses produced with fluxes containing potash, lime or lead.

In recent years, the increasing number of analyses carried out on Western European glass dating from this transition period has highlighted the presence of a great variety of compositions. This diversity seems to reflect the use of local raw materials, which enabled glassmakers to address the lack of both raw and recycled natron glass. Different case studies of glass workshops will be used to illustrate some original solutions developed to maintain the glass manufacturing.

Phelps, M. 2018. Glass supply and trade in early Islamic Ramla: An investigation of the plant ash glass. In, *Things that Travelled, Mediterranean Glass in the First Millennium CE* (Daniela Rosenow, Matt Phelps, Andrew Meek and Ian Freestone Eds.), pp. 236-282. London: UCL Press.
Henderson, J. 2013. *Ancient Glass: An Interdisciplinary Exploration*. Cambridge: Cambridge University Press. Chapters 2, 4 and 9.
Schibille, N., B. Gratuze, E. Ollivier, E. Blondeau and D. Bornemann *(submitted). The complete chronology of early Islamic glass compositions from Egypt.*

The Conservation of Glass

Stephen Koob, The Corning Museum of Glass, USA

Cleaning glass: Cleaning is often done to improve the appearance of a glass. However, archaeological glasses should not always be cleaned as this can remove original material. Historic and modern glasses can often be safely cleaned, but must be evaluated individually.

Repairing broken glass: Because it is almost impossible to refuse broken fragments of glass, synthetic adhesives are used to re-join the pieces. Two different adhesives are recommended for the repair of glass: Paraloid B-72, and epoxy resin adhesives. B-72 is an acrylic co-polymer and prepared as a resin:solvent solution. Epoxy adhesives are more complex thermosetting resins and require very precise mixing proportions.

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The advantages of B-72 adhesive include stability, reversibility, fast setting time, and low cost. It can also be used as a consolidant for strengthening fragile or deteriorated glass. Epoxy resins are often used on clear, transparent glasses and for large structural repairs.

Storage and care of glass collections: All glasses should be stored in a well-ventilated and climate-controlled environment. The humidity should ideally be between 40-50%. Temperature can vary considerably, if it does not change the humidity. Historic and modern glasses can slowly deteriorate from high humidity fluctuations, but most archaeological glasses are less susceptible to this problem.

Typology of Glass Beads: Techniques, Shapes, Colours, and Dimensions

Joanna Then-Obłuska, Centre of Mediterranean Archaeology, University of Warsaw, Poland

This paper presents an approach to glass bead typology which is based principally on the techniques of perforation of the bead body and subsequently on decoration technique. A bead body can be a section of a drawn glass tube. Otherwise, molten glass can be wound around a rotating mandrel to form a bead. Glass strips can be folded, or joined around a mandrel to form a bead. Glass can also be rod-pierced with a mandrel. The morphological description of glass beads (i.e., centrally perforated objects) follows the terminology of Maud Spaer (2001) and Peter Francis Jr (2002). Both authors are also referenced in the provenance studies of bead manufacturing techniques.

Following the classification of Horace Beck (1928), the geometrical shape of the bead can be combined with its length and described as disc, short, standard or long. When classifying a bead, one of the important characteristics to look at is a bead's colour. The most optimal way to identify a bead's colour is to use the Munsell Colour Book. However, in addition to providing the bead's basic colour, the level of diaphaneity is also useful.

This presentation is richly illustrated by bead examples coming from excavations at Roman and Late Antique sites in Northeast Africa.

Beck, H.C. 1928. I. Classification and nomenclature of beads and pendants, *Archeologia (Second Series)* 77: 1–76.
Francis, P. Jr. 2002. *Asia's Maritime Bead Trade: 300 B.C. to the Present.* Honolulu: University of Hawai'i Press.
Spaer, M. 2001. *Ancient Glass in the Israel Museum: Beads and other small objects.* Jerusalem: Israel Museum.

PROTOGLASS AND FAIENCE

Glazed Steatite and Faience Technology at Harappa, Pakistan (3300-1900 BCE): Technological and Experimental Studies of Production and Variation

Jonathan Mark Kenoyer, University of Wisconsin-Madison, USA

Excavations at the site of Harappa, Pakistan have revealed important archaeological evidence for the development of glazed steatite and faience production in the Indus Civilization. This paper will focus on the discoveries of glazed steatite and faience slag from the Ravi Phase occupations (3300-2800 BCE) and the development of more complex glazing and faience technologies during the subsequent Kot Diji Phase (2800-2600 BCE). The main focus will be on the diverse range of glazed steatite and faience production during the Harappa Phase (2600-1900 BCE). During the Late Harappa Phase (1900-1700 BCE) at the site there is evidence for continued production of both glazed steatite and faience. The chemical composition and technology of archaeological examples will be compared with experimental replicas to better understand the possible stages of production and recipes used to make both glazes and faience. The implications of Harappan glazing and faience for later developments of glass will also be discussed.

An Archaeometric Perspective on the Technology and Raw Materials of Faience Production in Harappa and Mohenjo-Daro (Indus Valley, Pakistan)

Ivana Angelini, Cinzia Bettineschi, Massimo Vidale and Gilberto Artioli, University of Padova, Italy

The presentation will focus on the compositional recipes and the production technologies of the early vitreous materials manufactured during the Late Harappan period (ca. 2600-1900 BCE) by the Indus Valley Civilization. In particular, we will present the results of the archaeometric investigations carried out on a set of 5 bangles and 1 slag from Harappa and 3 ornaments, 1 slag and 1 bone with glass residues from Mohenjo-Daro.

Technological investigations on the production markers were first performed by non-invasive high magnification 3D images recorded by a stereomicroscope. Subsequently, X-ray Diffraction (XRD) was performed on polished sections for the characterization of the crystalline phases. Microtextural and chemical data were obtained thanks to a combined protocol of optical (OM) and electronic imaging (SEM-EDS) and Electron Microprobe analyses (EPMA).

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While the faience ornaments of Harappa and Mohenjo-Daro seem to be manufactured using slightly different raw material proportions, their production process show interesting similarities not reported in the previous studies. Specifically, we identified the use of the direct application method for the surface glaze layer. According to our interpretation, glaze was applied in the final production step, using a slurry with a different composition from the interparticle glass in the body of the samples. The chemical and mineralogical data related to this and to other open questions will be presented and discussed in detail during the contribution.

Pre Iron Age Glass in India

Bhuvan Vikrama, Archaeological Survey of India

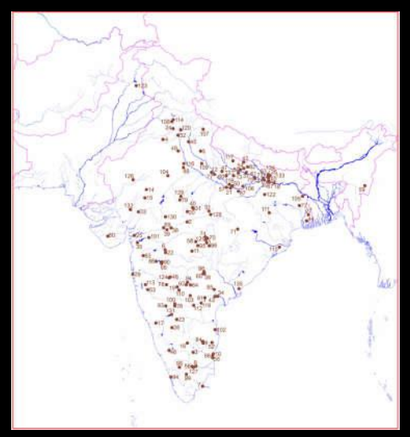
Glass manufacturing attained a high degree of technological perfection in ancient India. Whereas in other parts of the world evidence of glass production is available for a period ranging from 2500 to 1500 BCE, in India, glass does not seem to be present before 1000 BCE, despite the existence of culturally rich and technologically sophisticated societies. Chalcolithic cultures like the Harappan did not produce glass; however, high quality faience dating from that early period is fairly common. Muhammad Sana Ullah, who first studied the faience found at Harappan sites, doubted that it was “of the nature of glass” despite its fine quality This paper considers pushing back the antiquity of glass to 2000 BCE and even beyond following the evidence found at the Sakatpur and Harinagar sites. These evidences, although scanty, are quite convincing based on the AMS dating of the archaeological context where they were found.

GLASS IN SOUTH ASIA

PART I: ETHNOGRAPHY & LITERATURE

Glass in Ancient Indian Text vis-à-vis Archaeology

Alok Kumar Kanungo, IIT Gandhinagar



Glass in India is periodically mentioned in the Brahmanical, Classical and Buddhist literature. The reference of glass is also found in the mythologies of Mahabharata and Ramayana. In the recent past, the cultural artefacts which have generally been associated with these mythologies were found from the 2nd millennium BCE in respectable numbers and from quite a few sites. This had previously been believed to be from the 1st millennium BCE. No texts prior to Artha stra refer to the manufacturing process and fuel used in glass working. In all Sanskrit literature, prior to and after Artha stra, the term k ca is used for glass; however, little information is provided about recipes and glass technology. Those written records deal mostly with the role of glass in Indian society and traditions. Thus development of glass in the Indian subcontinent needs to be evaluated in both literature and archaeological evidences.

GLASS IN SOUTH ASIA

PART I: ETHNOGRAPHY & LITERATURE

This paper seeks to examine the evidence of glass working, glass making and its distribution in the Indian Subcontinent by comparing the archaeological vis-à-vis literary evidences of respective time periods.

Glass Beads and Glass Ornaments of Tamil Nadu, South India: A Study Based on Archaeological and Textual Sources

V. Selvakumar, Tamil University

Man-made beads were used in Tamil Nadu starting in the Iron Age, although they may have been introduced in the earlier Neolithic period. The Iron Age-Early Historic megalithic burials have carnelian, quartz and amethyst beads and possibly faience beads placed as offerings. Although glass beads appear during the Early Historic period, they are absent from the megalithic burials. Perhaps people did not consider them traditionally significant or valuable as they did with carnelian or other stone beads. Perhaps, they were used by only a certain part of the population. The glass beads might have been introduced as the result of Early Historic commercialization.

They are found at habitation sites and occur in several chronological contexts: Early Historic, Medieval, Late Medieval and Modern contexts. In the Early Historic context, bead making sites such as Arikamedu and Kudikkadu existed. Many sites have beads in various hues and colours. The glass bead and bangle makers were very well known in the Late Medieval and Modern periods with specialized groups called Valayalkarachettis (bangle making chettis) and evidence of the bangle making chettis appearing at many sites in Northern Tamil Nadu. The offering of glass bangles is often associated with the temples of Mariamman in the modern period. The tradition of ceremonial bangle wearing is often associated with pregnant women. In the Medieval period, the glass beads became part of the thali or mangala sutra of certain communities. This shows that the glass beads and ornaments have a long association with the history and culture of Tamil Nadu. The proposed paper seeks to survey the history of the use of glass beads and glass ornaments in Tamil Nadu from the Early Historic to the Modern period based on archaeological and textual sources.

The Technology behind the Traditional Production of Mirrors

Jan Kock, Aarhus University and Torben Sode, Glass Bead Trading, Denmark

Mirrors have always fascinated mankind because of the possibility to see one's self in them and because of the belief in a life on the other side. So, the need of mirrors has always been there. For the first mirrors, polished metal was used. The earliest glass mirror was found in Egypt and was dated from the first or second century BC. Pliny the Elder (23-79 CE) mentioned its invention in Sidon, Lebanon. For the first mirrors, the mirroring was based on lead and the glass itself was always curved. Viking Age burials from about 1000 CE sometimes contain small curved mirrors. In the 15th century the flat mirror technique was invented in Murano Italy.

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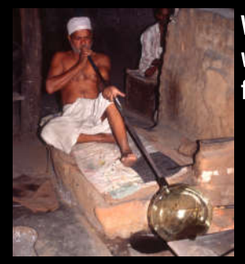
PART I: ETHNOGRAPHY & LITERATURE



We have been looking for decades for a place where the old technique of mirroring with lead was still alive. The best place was in Kapadvanj, Gujarat, India. The production there will be put forward in details and compared with the European mirrors.

The use of Traditional Made Mirrors in India in Buildings, Clothing and Daily Life

Jan Kock, Aarhus University and Torben Sode, Glass Bead Trading, Denmark

This paper will present the different uses of Indian made curved mirrors in buildings, clothing and daily life. Great palaces and small mud houses can have both the interior and the exterior decorated with small curved mirrors in a combination of tradition and style. Flat mirrors are also in use but have to be imported from Europe and for that reason are expensive. Also dresses for women can be fitted with many small mirrors. In the 1960s-1970s, it was nearly a worldwide fashion. At the night market in Ahmedabad and the Gujarat market at Janpath in New Delhi you still will find many items both new and old decorated with these mirrors. The use of the traditional small mirrors is now disappearing. It is easier to use mirrored flat glass or more often mirrored plastic.

Glass Crafts in Northern India

Alok Kumar Kanungo, IIT Gandhinagar

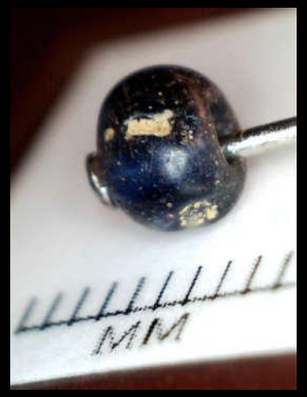
The origin of glass in the Indian Subcontinent may be unclear but it is well established that it first appeared in Northern India. The evidence suggests that production of glass in this part of the sub-continent was an indigenous initiative that took place prior to the 1st millennium BCE. Since then the glass crafts in northern India seems to have developed and diversified many fold. Not only the local craftsmen retained the innovations made for thousands of years but in the last hundred years they imported, imitated or adapted many glass working methods, at times overtaking the original place of production.

The traditional glass industry of northern India and in the villages of Jalesar-Purdalpur-Akrabad, which have dominated the market of glass adornment products for centuries, is on the verge of extinction. This paper presents an ethnohistorical documentation and ethnoarchaeological interpretation of the glass and its by-products like that of beads and bangles in Northern India.

A Review of the Glass Bead Types from the 2007-2009 Seasons of Excavation at Pattanam, India

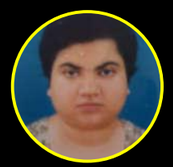
Shinu Abraham, St. Lawrence University, USA

Over the last decade, excavations at the archaeological site at Pattanam in Kerala, India, have produced a range of material data related to South India's involvement in early Indian Ocean exchange networks. One such category are glass beads, an archaeological corpus from the site that now number over 100,000. By far the most common type of glass bead from Pattanam is the Indo-Pacific bead, a small monochrome drawn bead that was likely produced in South Indian glass bead workshops. But along with Indo-Pacific beads were a variety of other distinct glass bead types, most of which were not made by the drawing method and whose production origins are less certain. A number of them have parallels from other sites in South Asia and elsewhere along the Indian Ocean littoral. These bead categories include gold glass beads; large faceted types that may imitate beryl gemstone beads; polychrome 'zone' beads that mimic banded agate beads; large drawn barrel beads; and terracotta disc beads. This presentation will draw on the examination of roughly 3,000 glass beads from the 2007, 2008, and 2009 seasons, which were individually studied and catalogued. In addition to reviewing the stratigraphic and depositional contexts for these Pattanam beads, each bead type will be considered in terms of their typology, known regional/chronological distributions, possible production venues, and their utility in providing further insights regarding Pattanam's position as a node within a complex suite of inland and maritime exchange networks.



A Review of the Glass Bead Types
from the 2007-2009
Seasons of Excavation at Pattanam, India

Glass Beads of Eastern India



Sharmi Chakraborty,
Centre for Archaeoloical Studeis and Training, Eastern India

Archaeological record of beads from eastern India has been very sketchy and not standardized. Therefore only a general idea of glass beads is given. The data used in this work is biased toward Bengal because better records are available from this region.

The colours include various shades of green and blue, black, opaque white, translucent red, Indian red, yellow and orange ochre and violet. There are composite beads of sandwich type, inlaid, millefiori, gold foil type and occasionally cemented type. It appears from the current dataset that there is a distinction between the coastal sites and the inland sites. While the inland areas have more green and blue glass, the coastal area has ochre red, yellow and orange. The latter group is well known as Indian Ocean beads.

Of the different shapes that are found here barrel types predominate. There are also good proportions of cylinder circular and disc beads. Facetted beads are few.

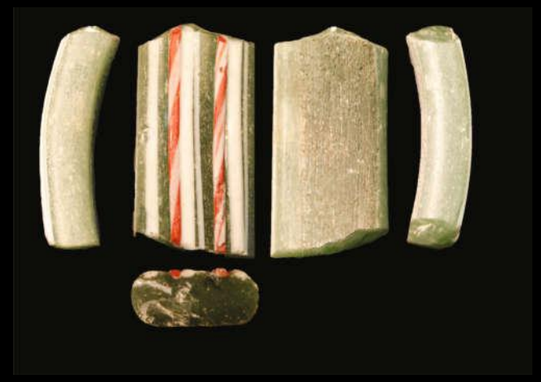
Another interesting feature that can be noticed in this region is two types of composite glass beads that tend to imitate agate.

GLASS IN SOUTH ASIA
PART II: GLASS IN DIFFERENT PARTS OF SOUTH ASIA

Glass bangles in Medieval India: Revisiting Typological Variation, Technological Change and Cultural Significance of a Key Artifact Type

Mudit Trivedi, University of Chicago, USA

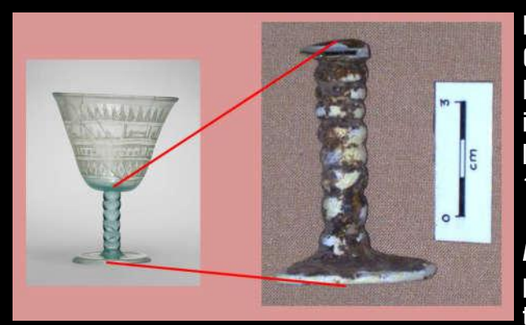
This paper presents a review of the archaeological evidence for glass bangles in India with a particular focus upon North Indian medieval assemblages. While glass bangles are profuse in both abundance and variation, despite this profusion, there are neither detailed studies nor any regional typology. Thus, in contrast to other glass artifacts we have a limited sense of historical shifts in typology, production techniques and organization, and exchange networks for an artifact type that even today serves as a media of marked cultural and gendered salience.



This paper addresses these openings by providing first, a historiographical review of the study of glass bangles - locating the Indian scholarship within that of glass bangles in the Levant, Hijaz, Yemen and north Africa. Within the long-term evidence for glass bangles in India, the paper provides a detailed description of the specificity of polychrome ornamented bangles in the medieval period. Evidence for marked typological change in an extensive assemblage from the site of Indor (Rajasthan) and a new typology developed for their analysis shall be discussed. The paper closes with a review of the possibilities bangles uniquely offer for the study of typological and cultural change in glass cultures in India.

West Asian Glass in Early Medieval India as Seen at the Excavations of Sanjan

Kurush F. Dalal and Rhea Mitra-Dalal, Mumbai University



Prior to the excavations at the site of Sanjan, Dist Umargam, Gujarat from 2002-2004, very little if anything was known about Early Medieval glass and even less about the possible import and influences of glass from West Asia during the intense period of Indian Ocean Littoral trading during the early Islamic Period (8th - 13th c. CE).

After the fall of the Sassanian Empire in 641/651 CE there was much persecution of the local Zoroastrians and a group of them escaped to the hills of Khorasan. They descended a hundred years later to the Maritime Silk Route from the Persian Gulf to China.
Hormuz and after a wait of 30 years they left for the west coast of India. Ultimately they made landfall on mainland India at the site of Sanjan. Here they tried to rebuild their lives and continued to follow the worship of their choice till the site was deserted in the late 13th/early 14th c. CE. Whilst excavating here for three seasons (2002, 2003 & 2004) we realised that we were looking at the remains of an urban Early Medieval centre engaged in trade with West Asian Traders trading the Maritime Silk Route from the Persian Gulf to China.

GLASS IN SOUTH ASIA

PART II: GLASS IN DIFFERENT PARTS OF SOUTH ASIA

Amongst the artefacts recovered during the excavations we encountered huge numbers of glass fragments. This discovery was unanticipated. It was also unprecedented, perhaps due to the lack of investigations into this period in this region. Subsequent academic perusal of this database led to the identification of numerous shapes as belonging to the period between the 10th and 12th c. CE which much to our surprise were made in workshops in West Asia and Asia Minor. This opened a new chapter in the research into glass in the Indian subcontinent.

This paper is a review of our work done on the glass objects recovered from the Sanjan Excavations. It includes not just the foreign glassware but also lists the continuing Indian traditions of beads and bangle manufacture which continued side by side with the imports.

A First Look to the Development of Glass and Glassy Materials Industries in the Sequence of the Early Historic Site of Barikot (Swat, Khyber Pakhtunkhwa, Pakistan)

Cinzia Bettineschi, Ivana Angelini, Massimo Vidale, University of Padova, Italy; and
Luca Maria Olivieri, ISMEO, Roma

The authors are carrying out an analytical program on the ornaments and fragmentary containers in glass and faience recovered in recent digs at the site of Barikot (Bir-Kot-Ghwandai, ca. 1300 BCE-300 CE). While the microstructural and chemical study of the vitreous materials is still in its preliminary stage, we will present the artifacts under study from a typo-chronological and technological viewpoint, and their stratigraphic and historical contexts. In particular, we will discuss the different classes of materials discovered in the site (beads, vessels, bangles, possible production waste) and their relative abundance in the considered timespan. Very careful excavation methods, abundant AMS 14C dating on carbonized seeds, a tight chronological sequence of ceramics and coins contribute to reconstruct a very coherent framework that reflects in a new light the introduction of glass-related craft industries in the north-western regions of the Indo-Pakistani Subcontinent.

Glass in Ancient Sri Lanka: Production and Use of Glass, Glass Beads and Banglesn

Wijerathne Bohingamuwa, University of Ruhuna Matara, Sri Lanka

Beads and bangles are considered as some of the earliest products made of glass in the ancient world. Glass beads have been made, used and traded at least since 2000 BCE and have since been one of the most desired raw materials of bead production. Glass beads have been found in large quantities in Sri Lanka, the vast majority of which were locally made. They occur across archaeological sites from ca. 600 BCE. Although less in quantity, glass bangles are also found alongside beads.

Sri Lanka was one of the key centres of Indo-Pacific glass beads, which were traded across the Indian Ocean. Such large-scale production of glass beads required an enormous amount of glass, sources of which are yet to be reliably identified. This paper considers locally made glass beads and bangles found along with their production debris and glass slags as

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PART III: CIRCULATION OF SOUTH ASIAN GLASS BEYOND SOUTH ASIA

possible evidence for the earliest production and use of glass in Sri Lanka. This is in addition to limited evidence reported for glass production at Giribawa and Ridiyagama, re-melting of broken glass at Mantai and importation glass from Godavaya. This paper, based on the present author's work at Mantai and Kirinda as well as published material from Mantai, Anuradhapura and Tissamaharama, reassesses the production and use of glass in Ancient Sri Lanka.

Indian Glass Beads in Western and North Europe in Early Middle Age

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In recent years, chemical analyses of glass beads excavated from Late Antique and Early Middle Age sites in Western and North-western Europe (France, Belgium, Switzerland, Denmark, Germany and Sweden) have revealed for the first time the presence of two groups of glass beads with unexpected compositions for these periods and geographic areas.

The first group is composed of tiny (less than 1.5 mm diameter) glass beads recovered from Merovingian (mid-5th/6th c. CE) graves located in Western Europe. Although their chromatic spectrum is varied: green (more than 6,300 examples), orange with a red core (233 examples), black (184 examples), yellow (18 examples), slightly translucent “milky” white (5 examples), and red (3 examples), we observe a predominance of green beads (93% of the total studied here) which may express a preference for this colour.

Up to now, only beads recovered in France, Belgium and Switzerland have been analysed. But according to their particular typology, these beads have also been identified in The Netherlands, Germany and Spain. Their glass has a high-alumina soda composition which was proved to be identical with the one identified by Dussubieux for small drawn 'Indo-Pacific' beads produced in southern India and Sri Lanka from the 3rd c. BCE through the 7th c. CE (composition referenced as m-Na-Al 1, Dussubieux et al. 2010). The second group is composed of large opaque red or orange barrel-shaped beads (ca 10-12 mm diameter) found in early 7th century graves in North-Western Europe. The beads studied here originate mainly from Denmark (Ribe and Sandegård - Bornholm island), Sweden (Helgö and several sites on Gotland island) and Germany (Frankfurt Harheim). At Helgö in Sweden, where large numbers of this type of beads were discovered, a Buddha statue and cowries shells were also found in the same levels. Most of the analysed beads from this period were made from recycled Roman glass. However, some of them, only made with red and orange glasses, show a composition which differ from all known Western European glasses in both main components composition and colouring recipe. Their trace element pattern, although not identical, shows several similarities with those of South Asian glasses.

The presence of these glass beads is new evidence for trade relations between Western Europe and the Indian Ocean region between the 5th and the 8th centuries. While previous work on South Asian garnet inlays in Merovingian jewelry (Greiff 1999) provides additional background, what is new about the glass bead evidence is that it suggests that Western European-Indian Ocean long distance exchanges involved more than rare luxury goods such as silks and precious stones, and that many other products may have been traded between Europe and South Asia in the Early Middle Ages.

Dussubieux, L., B. Gratuze and M. Blet-Lemarquand 2010. Mineral soda alumina glass: occurrence and meaning, *Journal of Archaeological Science* 37(7): 1646-1655.
Greiff, S. 1999. Naturwissenschaftliche Untersuchungen zur Frage der Rohsteinquellen für frühmittelalterlichen Almandingranatschmuck rheinfränkischer Provenienz, *Jahrbuch des Römisch- Germanischen Zentral Museums Mainz* 45(2): 599-645.

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Indian Glass Beads of Eastern and Southern Africa

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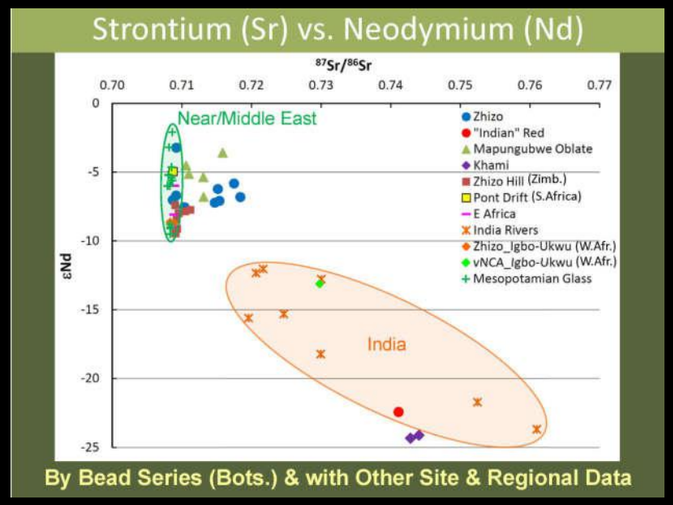

Glass beads, while not always in great numbers, are ubiquitous at coastal and inland archaeological sites of the 1st and 2nd millennium CE in eastern and southern Africa. These beads have generally been classified into "type" series, with temporal ranges typically spanning two to three centuries. However, these type series did not provide enough information about potential origins for the beads, and so interpretive efforts to better understand supply and trade networks, and ancient economies were hampered. Chemical analyses of glass beads from these regions were conducted to better understand similarities /differences within and between the bead series, and to establish some provenance.

While initial attempts in the 1970s advanced these questions, it was not until renewed efforts were made in the 2000s, using new and improved analytical methods, that significant progress was made. Since that time, a growing number of chemical analyses have been conducted on beads from sites in eastern and southern Africa, as well as on comparative materials from several important potential source regions (e.g., Southwest Asia, South Asia, Southeast Asia, etc.), providing a much more robust interpretive tool. One of the observations derived from these data is the importance of glass beads presumably originating from India in the African collections. Several compositional groupings have been established, and certain "recipe" distinctions have been identified which suggest that during certain periods within the bead types-series, India was a major source for glass beads arriving on the East African coast and working their way down to southern Africa and into the interior of the continent. The addition of a modest number of isotopic analyses also has helped suggest links between some glass bead chemical groups and India. As the work on African beads continues and as similar compositional and isotopic research on glass beads and raw materials is expanded to India, the potential for more convincing and definitive connections to India in general and to specific production regions within India grows. This paper will synthesize what we currently know about glass beads in eastern and southern Africa with particular emphasis on our current and growing understanding of their connections to India and include discussion of current work in India to develop a large-scale chemical and isotopic comparative dataset on raw materials used to manufacture glass beads in antiquity.

Glass in Southeast Asia

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For the last decade Southeast Asia has been an area where glass research has been extremely active. Although many questions remain unanswered, a clearer picture in terms of organization of the glass industry and trade exchange through time has emerged. Myanmar with familiar compositions but with very local typologies.

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At a very early period (4th-2nd c. BCE), glass ornaments were manufactured in modern Thailand using techniques and raw materials imported from northeastern India and other regions, possibly within Southeast Asia. Production from these very early workshops was distributed around the South China Sea. At the same early period, production centers located in other regions of Southeast Asia might have operated too as evidenced by the very specific type of beads found in modern Myanmar with familiar compositions but with very local typologies.

Around the 2nd-1st c. BCE, a shift occurs with the loss of the northeastern Indian connection and instead glass beads from southern India and/or Sri Lanka appears at certain Southeast Asian sites. Other sites present a very different glass pattern suggesting that different exchange networks co-existed for a while. Around the middle of the 1st millennium CE, available data becomes scarce and even if they indicate that ties with India seem to remain strong, more research would be necessary to define their nature and the intensities of the exchanges between the two areas. Another point that would need to be investigated is the disappearance around that time of certain primary glass productions. That might have created stimulation for more imports from India but also from the Middle-East and later from China. Around the 10th c. CE and later, connection with South India/Sri Lanka are still visible in Southeast Asia suggesting continuity over more than a millennium. In parallel, presence of beads possibly for northeastern India would indicate that a connection lost around the 2nd c. BCE was re-established.

Interrelations in Glass and Glazing Technologies in Mughal Architectural Tiles

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Glazed tiles were extensively used as a means of architectural embellishment in the medieval Islamic world. The Mughals employed them in significant numbers on their buildings over the sixteenth and seventeenth century. Laboratory investigations of Mughal tile glazes, sourced from a wide range of buildings spread over northern India, indicate the existence of two distinct compositional varieties. A reconstruction of glazing technologies shows that the two glaze varieties were differently made, one using a plant-ash flux as followed for glassmaking in the central Islamic lands, and the other with a mineral-soda flux as in traditional Indian glass production. Findings support the existence of a thriving glass industry in Mughal times, and the use of indigenous technologies in part for tile manufacture. In the larger context, the paper seeks to demonstrate the potential of archaeometric investigations in the study of tile glazes, notably to correlate regional craft practices with cultural exchanges through an assessment of technologies manifest in the archaeological record.

Glimpses of Ancient Trade between India and Kenya as Revealed from Analysis of Glass

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Archaeological excavations at Chaul on the west coast of India gave evidences of the production of Indo-Pacific glass beads. The beads are of various colours: blue, green, yellow and brick red. A reference to the production of small glass beads occurs in the travel account of Frederick, a Venetian traveler who visited Chaul in the sixteenth century. The occurrence of Indo-Pacific beads has also been recorded on the coastal sites of East Africa, particularly, at Mtwapa in

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Kenya. A strong similarity in appearance was found between the beads from Chaul and Mtwapa. The chemical analyses of major and minor elements by LA-ICP-MS have shown that the majority of beads from both sites are identical in all respects. Further, both sites show occurrence of similar monochrome glazed ware of blue, green and pink variety. The glazes were nearly one mm in thickness. A large scale production of this ware has been documented at Khambhat on the Gujarat coast. The glazes of monochrome ware from Khambhat, Chaul and Mtwapa compared chemically have again shown dramatically the same identity. The analyses of ancient glass beads and monochrome ware, thus, indicate that Chaul and Khambhat in India and Mtwapa in Kenya belonged to a wider international trade network.

A Review of the Glass Trade along the Maritime Silk Route (500 BCE – 500CE)

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The glass trade in the ancient world was a vital ingredient of the Old World economy. In particular, the movement of glass products (raw glass, glassware, beads) along the Silk Route of the Sea - from the Mediterranean regions to the Far East – contributed to the expansion of production centres and markets in the period under review. There was also the introduction of new technologies as well as the growth of 'syncretic' techno-cultural traditions in glass crafting. Two major maritime routes of the western Indian Ocean, the Red Sea and the Arabian-Persian Gulf routes to India, brought the best of the Mediterranean glass products (millefiori, blown glass) to south Arabia, east Africa and peninsular India. The western trade also engaged with ancient glass manufacturing regions of India, Southeast Asia and southern China, impacting the littorals of Korea and Japan. This paper intends to present a holistic picture of the glass trade along the Maritime Silk Route on the basis of the available archaeological evidence.

Indian Glass Beads in Northeast Africa between the 1st and 6th centuries CE

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Beads, next to pottery, are the most abundant archaeological material in Northeast Africa, often constituting the only evidence for direct and indirect trade contacts in archaeological records. While the connection of Northeast Africa to the Mediterranean world is well recognized, its link with Asian cultures is less known. This paper presents the chronological and spatial distribution of Indian glass bead imports as found in the territories of ancient Egypt, Nubia and Aksum during a time of intensive Indian Ocean trade. Chemical compositional analysis of chosen samples allowed confirmation of the South Indian/Sri Lankan provenance of monochrome and bichrome drawn and rounded beads. Looking for a more comprehensive picture of South Indian/Sri Lankan glass bead imports to Northeast Africa, many museum and site bead collections were macroscopically studied. As a result of this research, some Indian beads can be traced to Egyptian Red Sea ports in the Early Roman period that is between the 1st and the 3rd centuries CE. However, large scale glass bead imports are evident at sites on the Red Sea coast and in the interior of Northeast Africa in Late Antiquity, i.e. between the 4th and the 6th centuries CE.