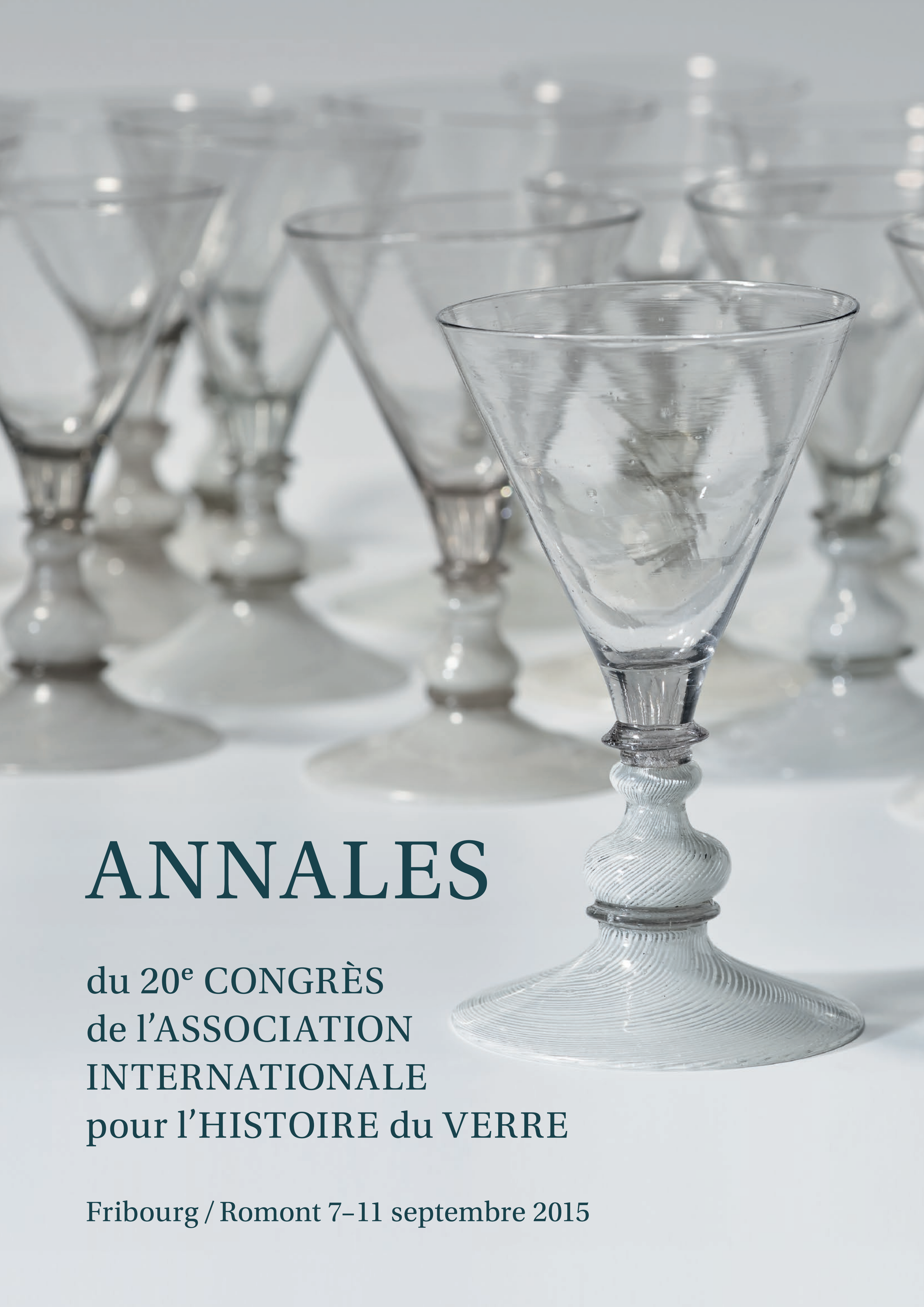
Red and orange high-alumina glass beads in 7th and 8th century Scandinavia: evidence for long distance trade and local fabrication

Torben Sode, Bernard Gratuze, James Lankton



ANNALES

du 20e CONGRÈS de l'ASSOCIATION INTERNATIONALE pour l'HISTOIRE du VERRE

Fribourg / Romont 7–11 septembre 2015

This volume is sponsored by Vitrocentre and Vitromusée Romont and by anonymous donators

VITROCENTRE ROMONT
CENTRE SUISSE DE RECHERCHE SUR LE VITRAIL ET LES ARTS DU VERRE
SCHWEIZERISCHES FORSCHUNGSZENTRUM FÜR GLASMALEREI UND GLASKUNST
SWISS RESEARCH CENTRE FOR STAINED GLASS AND GLASS ART

VITROMUSÉE ROMONT
MUSÉE SUISSE DU VITRAIL ET DES ARTS DU VERRE
SCHWEIZERISCHES MUSEUM FÜR GLASMALEREI UND GLASKUNST
SWISS MUSEUM OF STAINED GLASS AND GLASS ART

www.vitrocentre.ch

Cover illustration
Goblets with white filigree decoration, produced in Swiss glasshouses, late 17th to early 18th century. From different Swiss public and private collections. For a detailed discussion see: Erwin Baumgartner, Reflets de Venise, Bern 2015, p. 254–272, 322–328 and the contribution of Christophe Gerber in the present volume, page 564.

Editors
Sophie Wolf, Anne de Pury-Gysel

Editing Committee
Erwin Baumgartner, Sylvia Fünfschilling, Marion Gartenmeister, Anne de Pury-Gysel, Stefan Trümpler, Sophie Wolf

Layout
Andrea Engl and fischbacher & vock

Cover and book design
fischbacher & vock

AIHV
Association Internationale pour l'Histoire du Verre
International Association for the History of Glass
Internationale Vereinigung für die Geschichte des Glases
www.aihv.org

Romont 2017

Gesamtherstellung
VML
Verlag Marie Leidorf GmbH,
Geschäftsführer: Dr. Bert Wiegel,
Stellerloh 65 · D-32369 Rahden/Westf.
Tel.: +49/(0)5771/9510-74 · Fax: +49/(0)5771/9510-75
E-Mail: info@vml.de
Homepage: www.vml.de
Gedruckt auf alterungsbeständigem Papier
Druck: druckhaus köthen GmbH&Co. KG, Köthen

ISBN 978-3-86757-024-4

CONTENTS

RED AND ORANGE HIGH-ALUMINA GLASS BEADS IN 7TH AND 8TH CENTURY SCANDINAVIA: EVIDENCE FOR LONG DISTANCE TRADE AND LOCAL FABRICATION

Torben Sode, Bernard Gratuze, James W. Lankton

INTRODUCTION

In a research project on glass from the Viking Age market in Ribe, southwestern Jutland, Denmark,[1] nearly 200 samples of raw glass, mosaic tesserae, vessel fragments, waste from bead production and finished beads were analysed by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Among these, one red and two opaque orange barrel-shaped beads had a unique high-alumina composition that seems to be closely related to small, drawn, monochrome 'Indo-Pacific' beads known to have been produced in South and Southeast Asia,[2] but with trace elements different from any other known glass types.

Relatively large opaque orange and red glass beads (6–10 mm diameter) are very common in southern Scandinavia between the early 7th and early 8th century CE. Especially in the Mälaren region in Sweden and on the Swedish island Gotland and the Danish island Bornholm in the Baltic Sea, these beads are found in large numbers. Although most are barrel-shaped, they may also be rounded, square, cylindrical or conical, as well as faceted into cornerless cubes. The beads were used both in necklaces and as colourful elements in beaded breast ornaments, often arranged in four to five rows containing more than 100 beads, kept in position with bead-string spacers and terminal elements fastened to the woman's dress just below the shoulders. Such exclusive jewellery was most probably used by women from the social elite, and sometimes included gilt-bronze fibulas and brooches, some inlaid with garnet or glass.[3]

Beads in Scandinavia from the 7th century were dominated by monochrome orange and red, although opaque yellow, white and green, as well as transparent blue and a few polychrome glass beads, are also found. By far the most common bead material is glass, with a smaller number of copper-alloy, amber and tropical marine shell beads. New types of ornaments, including long facetted drop- or pear-shaped amethyst, cornelian and rock crystal beads, first appear in the 7th century as well. By the early 8th century, the fashion for large beaded breast ornaments with orange and red beads had changed in most places to jewellery with a dark blue palette, with monochrome transparent blue ring-shaped, melon and cornerless cube beads, accompanied by blue beads with red, white or yellow trailing, eye beads and mosaic beads with checkerboard patterns. The domination of blue beads continued until the late 8th century, when imported mosaic glass beads, monochrome drawn beads, silver gold foil beads and other beads manufactured in the Near East became popular.[4]

Fig. 1: Location of the different studied sites. © B. Gratuze.

In Western Europe, most glass objects that circulated from the 1st century BCE to the 9th century CE were made from Near Eastern or Egyptian soda-lime glass produced from low-alumina calcareous sand plus natron, hydrated sodium carbonate, probably collected from lakes near Wadi Natrun, Egypt.[5] Several centres of raw glass production, primary workshops, functioned during this period.[6] In Western Europe, the production centres for vessels and beads, secondary workshops, used blocks of raw glass from primary workshops and/or recycled glass (cullet, tesserae). Chemical and isotopic analyses have enabled characterisation of these productions.[7] Although there are several

1 Andersen and Sode 2012, 17–59.
2 Francis Jr. 2002, 17–50; Dussubieux and Gratuze 2013, 399–414; Lankton and Dussubieux 2013, 415–444.
3 Becker 1955, 26–34; Iversen and Näsman 1978, 85–104.
4 Nielsen 1987, 47–86; Callmer 1997, 197–202; Sode, Feveille and Schnell 2010, 319–328.
5 Shortland et al. 2006, 521–530.
6 Freestone, Gorin-Rosen and Hughes 2000, 65–83; Rehren et al. 2010, 65–81.
7 Summarized in Degryse (ed.) 2014.

Fig. 2: Glass beads from Grave K51, Nørre Sandegård, Bornholm. Range of shapes (left) and necklace *in situ* (right). Photographs © Bornholm Museum.

sub-groups,[8] probably related to the geographic origin of the primary workshops or to particular combinations of elements, the overall compositions are relatively similar.

Although natron-based glass was dominant, a second compositional group, made with soda from the ashes of halophytic plants, continued through Antiquity to the 9th century. These glasses have higher contents of potash (K_2O), magnesia (MgO) and phosphate (P_2O_5). Two families of plant ash soda glass have been identified. The first, found mainly in red and green mosaic glasses,[9] is distinguished by similar contents of magnesia and potash. For the second type, magnesia is higher than potash; these glasses were probably produced inland in Mesopotamia.[10]

The Mediterranean glasses, whether based on mineral or plant-ash soda, are characterised by an alumina content from 2 to 3 wt %, rarely exceeding 4 to 5 wt %, with the most important exceptions being a group of higher-alumina Byzantine glass vessels associated with Anatolia.[11] Most of the glass objects that we analyzed from 7th century Scandinavia, like those of Antiquity, were produced from the different soda-lime natron glasses that originated from Egypt and the Levantine coast.

The unusual glasses reported here and presented in more detail in the Results and Discussion sections below, are quite different from the natron, plant-ash or higher-alumina Anatolian glasses found in Europe and the Middle East, being much more similar to several types of high-alumina glass known to have been produced in South and perhaps Southeast Asia, from the late 1st millennium BCE until at least the end of the 1st millennium CE.[12]

ARCHAEOLOGICAL QUESTIONS

We were surprised to find what appeared to be Asian glass among the typically North European ornaments at Ribe. Even though the number of examples from Ribe was low, such orange and red barrel-shaped beads, often referred to as *glass flus* beads, are well known in Scandinavia. We wondered if the Ribe 'Asian' glass might be part of a larger pattern, and began a broader study to answer the following questions:

1. What chemical types of glass were used to make the predominantly barrel-shaped opaque red and orange beads found in Scandinavia?
2. If more Asian glass were found, over what period was it present in Scandinavia and where was it produced?
3. Were unworked glass fragments or finished beads imported?
4. What might be the possible long-distance exchange routes for Asian glass to reach Scandinavia?

MATERIALS

We studied a number of glass bead assemblages from sites in Scandinavia and a few from northwestern Germany dating to the 7th and 8th centuries. In addition, because female graves from the Late Roman and Early Germanic Iron Age in Scandinavia (200–600 CE) often contained substantial sets of jewellery, including a large number of glass beads, we wanted also to analyse some of the earlier opaque orange and red glass beads to see if we could find any pre-7th century examples made from high alumina glass. Figure 1 shows the geographic distribution of the studied beads.

Denmark

Besides the bead-making material from Ribe, the majority of beads included in our investigations were found on the Baltic islands of Bornholm and Gotland. On the northern coast of Bornholm, the 6th–8th century cemetery at Nørre Sandegård has been investigated several times since the early 20th century.[13] We selected 29 samples, mostly red or orange barrel-shaped beads from graves K30, K32. K46,

8 Foy and Picon 2005, 99–110.
9 Nenna and Gratuze 2009, 199–205.
10 Freestone 2006, 201–216.
11 Brill 1999, 110; Schibille 2011; Rehren et al. 2015.
12 Francis Jr. 2002, 17–50; Dussubieux and Gratuze 2013, 399–414; Lankton and Dussubieux 2013, 415–444.
13 Becker 1955, 26–34; Jørgensen and Jørgensen 1997, 27–35.

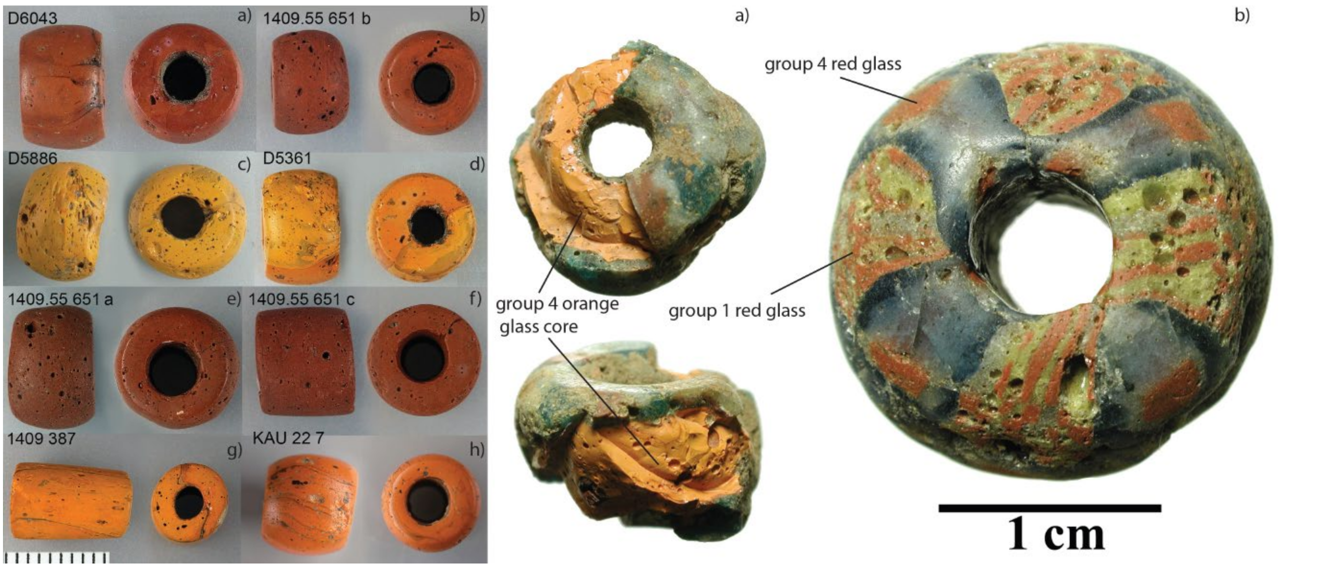


Fig. 3: Left: red and orange glass beads from Denmark (a, c, d, Ribe, 8th century; b, e, f, g, Nørre Sandegård, Bornholm, 7th and 8th century); North India (h, Kaushambi, approximately 1st to 4th century). Chemical compositions: group 1 (e, f), group 3 (g), group 4 (a, b, c, d), North Indian mixed-alkali (h). © J. Lankton. Right: Polychrome glass beads from Nørre Sandegård incorporating group 4 glass (a, BMR 1409 K2, 7th century; b, BMR 1409 K46, 8th century). See text for discussion. © Bornholm Museum.

K68 and K51, a high status female grave containing more than 120 beads arranged in four rows between two oval brooches. A selection of beads from K51 and a view of the necklace *in situ* are shown in figure 2. Also from Nørre Sandegård were two polychrome beads illustrated in figure 3 (right a and b): one with green glass over an orange core (a, grave K2, 7th century), the other a large blue bead with mosaic decoration (b, grave K46, 8th century).

From the Late Roman (200–250 AD) cemeteries at Vellensby on southern Bornholm, we selected eleven beads, including two cylindrical and four round red opaque beads, one bead with transparent green interior glass and a thin layer of red opaque exterior glass, one mosaic glass bead with a checkerboard pattern and three glass beads with mosaic eyes.

From Vindinge, a Late Roman and Early Germanic Iron Age (approximately 200–600 AD) cemetery near Roskilde in Denmark, we studied 25 beads, all dated to the 4th century, selecting examples that were morphologically most similar to the red and orange 7th and 8th century beads. These included eleven red opaque and six orange opaque barrel-shaped beads, several with sides and ends shaped by grinding.

Sweden

A grave dated to the second half of the 8th century at Smiss, in Eke Parish, Gotland, contained 46 mono- and polychrome glass beads, fifteen discoid beads made from local limestone and exotic shell, and numerous bronze ornaments including brooches with animal-head and interlace designs. We were able to study one red opaque glass bead, one opaque light blue bead with three applied eyes, and four additional samples including mosaic beads interpreted to have been produced locally. The late dating indicates that the fashion for orange and red beads continued longer on Gotland than in the rest of Scandinavia.

A wealthy female burial at Broa, Gotland, dated to the beginning of the 8th century, contained several rows of glass beads as well as bronze ornaments and bead-string spacers. We selected two red and two yellow glass beads for chemical analysis.

A late 7th century female grave at Uggårds, Gotland, contained 129 glass beads together with two bead-string spacers. We studied a total of 13 beads: two monochrome opaque orange, two monochrome red, two opaque light blue beads with applied eyes and seven beads decorated in the Gotlandic style with mosaic elements.

A treasure with gold, silver and bronze jewellery and 257 glass beads, dating to the 8th century, was found in 1983 at Nygårds on Gotland.[14] We selected one fragment of an opaque red bead, two opaque green beads with blue, white and red eyes, one opaque red bead with black and white eye decoration and one opaque light blue bead with a harlequin mosaic pattern.

In 1917, at Norrbys in northern Gotland, three rim fragments and eleven smaller pieces of a grey clay crucible containing the remains of opaque red glass were uncovered during farming activities. Associated finds included five complete and two broken opaque red glass beads, a disc brooch and a bronze buckle. The brooch and buckle date the finds to 600–675 AD.[15] While Nerman suggested that the crucible may have been used for making opaque red glass beads, melting red glass for inlays on bronze jewellery would be another possibility. We were able to study the rim fragments and two additional fragments from the crucible, as well as four opaque red beads.

The ancient Swedish trading town on the island of Helgö, located in Lake Mälaren about 30 km west of Stockholm,

14 Östergreen 1989, 160–161.
15 Nerman 1951, 252–253.

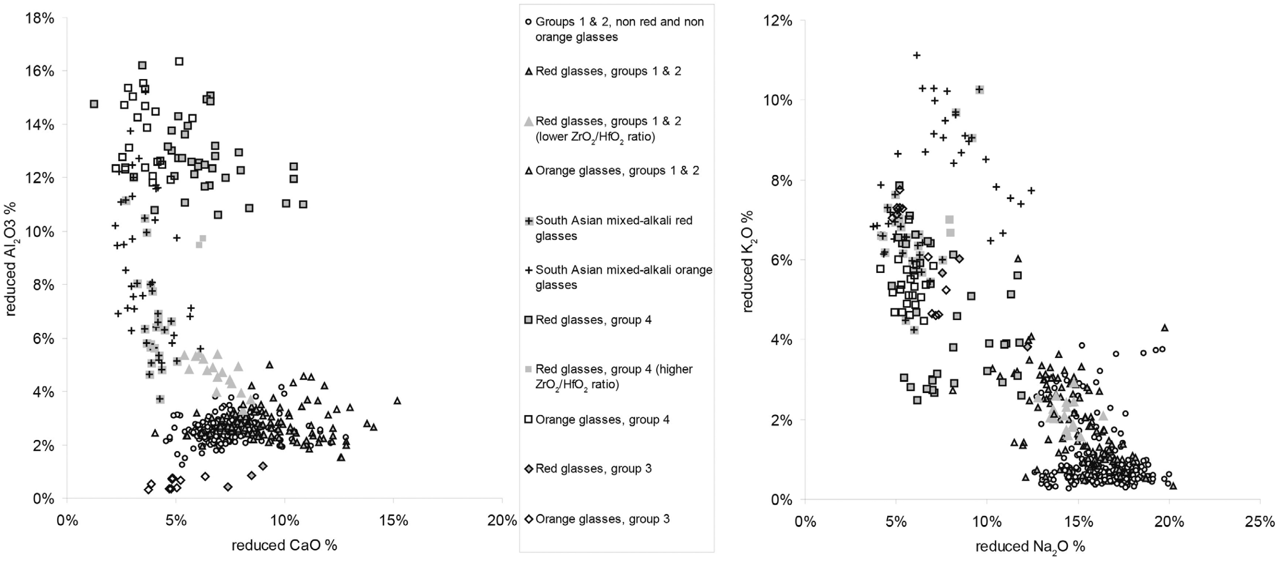


Fig. 4: Differentiation of glass groups according to contents (reduced composition) of CaO and Al_2O_3 (left), Na_2O and K_2O (right). © B. Gratuze.

was an important craft centre, particularly in the 5th and 6th centuries. The excavations revealed more than 1,400 glass beads, along with waste from glass bead production, including two beads melted onto the tip of an iron mandrel.[16] Some of the clay crucibles from the site may have been related, although our investigation of one crucible with a yellow glassy layer suggested metalworking, in accordance with earlier work.[17] Also found on Helgö were an Indian bronze Buddha, an Irish bishop's crozier with enamel and mosaic inlays, a Coptic Egyptian ladle, raw garnets, cowries and other exotics items,[18] all suggesting that the people on Helgö had various international contacts, extending directly or indirectly to South or Southeast Asia.

Germany

In connection with our research we had the possibility to analyse three red and three orange opaque glass beads from the 7th century cemetery at Harheim, in the city of Frankfurt a.M.

METHODS

We determined the chemical composition of 291 glass objects (raw glass, crucible contents, mosaic tesserae, vessel fragments, waste from bead production and finished beads) using LA-ICP-MS (laser ablation-inductively coupled plasma-mass spectrometry) at the Ernest-Babelon Centre (IRAMAT, UMR 5060 CNRS / Université d'Orléans). This method requires no sample preparation and is particularly well adapted to composite objects and to small objects like beads.[19] The glass fragments were placed inside an ablation cell, where a micro-sample, invisible to the naked eye, was taken by laser. This material was carried to a plasma torch by a gaseous flow of argon. The high temperature of the plasma (8000 °C) dissociates and ionises the glass, of which the different constituents are identified by an electronic detector according to their mass and charge. Accuracy and precision depend on a number of factors, including the mass and abundance of the measured isotopes and the background counts, but for most elements range from 5 to 10 relative % for major and minor elements up to 20 relative % for trace elements below 0.0001 wt %.[20]

Due to the presence of a large number of polychrome glass beads, we performed a total of 527 analyses. Among these were 48 opaque orange, 165 opaque red and 314 glasses of other colours (colourless, green, purple, white, yellow, amber, black, green, turquoise blue and dark blue).

Following chemical analysis, intact and broken opaque orange and red beads with different compositions were compared both macroscopically and microscopically in order to detect any differences in morphology or production method that might indicate different beadmaking traditions.

RESULTS

Chemical compositions

Using binary plots (Na_2O-K_2O, CaO-Al_2O_3, K_2O-MgO, MgO-P_2O_5, K_2O-P_2O_5), the compositional results enable classification of the studied glass into four groups (figure 4) according to the concentration of the main oxides associated with fluxes (Na_2O, MgO, K_2O, P_2O_5) or with sands (CaO, Al_2O_3). The first two groups correspond to soda-lime glasses elaborated with natron (group 1) or plant ash (group 2), commonly encountered in the western world. The two others (groups 3 and 4), have an unusual composition, characterized by the use of a mixed soda-potash flux, as described below. The group and subgroup mean compositions and standard deviations for 20 major, minor and trace oxides are listed in figure 5, along with numbers of samples. We have also included the calculated ratios ZrO_2 / HfO_2 (zirconium to hafnium as oxides) and CaO/SrO (lime to strontium oxide). Because high levels of colourants or opacifiers such as iron,

16 Lundström 1981, 1–38; Hansen 2011, 97–139.
17 Lamm 2008, 199–202.
18 Ljungkvist 2010, 419–441.
19 Gratuze 2013, 201–234.
20 Gratuze 2013, 210.

oxyde	Orange and red glasses group 4 (59)		Red glasses group 4 higher Zr/Hf ratio (2)		Orange and red glasses group 3 (15)		Orange and red glasses groups 1 & 2 (120)		Groups 1 & 2, non red and non orange glasses (314)		Red glasses groups 1 & 2 lower Zr/Hf ratio (17)		South Asian mixed-alkali red and orange glasses (56)	
	Average	*Std.*	Average	*Std.*	Average	*Std.*	Average	*Std.*	Average	*Std.*	Average	*Std.*	Average	*Std.*
Na_2O	6.3	*2.1*	7.2	*0.1*	4.9	*1.9*	13.0	*2.2*	15.0	*2.3*	13.0	*0.9*	5.6	*1.8*
MgO	0.7	*0.3*	0.9	*0.0*	0.6	*0.2*	1.6	*0.8*	1.0	*0.9*	0.8	*0.2*	1.6	*0.3*
Al_2O_3	11.5	*1.3*	8.7	*0.1*	0.5	*0.2*	2.4	*0.4*	2.3	*0.3*	4.2	*0.6*	6.7	*2.2*
SiO_2	61	*4*	61	*1*	57	*4*	59	*5*	65	*7*	64	*2*	57.2	*4.1*
K_2O	4.2	*1.2*	6.2	*0.2*	4.4	*0.9*	1.7	*1.0*	0.8	*0.6*	2.0	*0.3*	6.2	*1.4*
CaO	4.7	*2.1*	5.6	*0.1*	4.1	*1.7*	8.1	*1.8*	6.6	*1.3*	6.3	*0.8*	3.1	*0.7*
TiO_2	0.10	*0.02*	0.20	*0.004*	0.025	*0.010*	0.15	*0.04*	0.11	*0.04*	0.12	*0.02*	0.26	*0.10*
MnO	0.07	*0.03*	0.08	*0.001*	0.047	*0.011*	0.48	*0.26*	0.51	*0.46*	0.37	*0.11*	0.26	*0.19*
Fe_2O_3	2.00	*0.64*	2.25	*0.05*	1.26	*0.37*	2.31	*1.23*	1.03	*1.08*	1.90	*0.66*	3.42	*1.20*
CuO	7.6	*6.0*	4.2	*0.2*	20.4	*7.4*	3.3	*3.3*	0.4	*0.6*	3.3	*1.0*	13.3	*3.5*
ZnO	0.24	*0.40*	1.00	*0.07*	4.04	*1.85*	0.39	*1.17*	0.02	*0.07*	0.39	*0.68*	0.05	*0.06*
SrO	0.0087	*0.0043*	0.020	*0.000*	0.014	*0.004*	0.067	*0.020*	0.051	*0.013*	0.040	*0.006*	0.0096	*0.0018*
ZrO_2	0.0286	*0.0072*	0.0258	*0.0002*	0.0019	*0.0007*	0.0093	*0.0024*	0.0086	*0.0035*	0.0131	*0.0021*	0.0128	*0.0065*
SnO2	0.94	*0.38*	1.20	*0.03*	1.51	*0.24*	0.49	*0.43*	0.58	*1.28*	0.49	*0.16*	0.063	*0.148*
Sb2O3	0.019	*0.032*	0.010	*0.001*	0.023	*0.004*	0.42	*0.82*	1.40	*1.85*	0.65	*0.32*	0.0015	*0.0014*
BaO	0.013	*0.006*	0.042	*0.001*	0.015	*0.004*	0.030	*0.009*	0.029	*0.045*	0.024	*0.003*	0.031	*0.013*
CeO_2	0.021	*0.007*	0.019	*0.000*	0.0004	*0.0001*	0.0016	*0.0004*	0.0015	*0.0008*	0.0055	*0.0018*	0.0044	*0.0017*
HfO_2	0.0013	*0.0002*	0.00072	*0.00002*	0.00004	*0.00002*	0.0002	*0.0001*	0.0002	*0.0001*	0.0004	*0.0001*	0.0005	*0.0002*
PbO	0.059	*0.109*	0.073	*0.010*	0.39	*0.11*	5.04	*5.31*	4.3	*8.7*	1.44	*1.30*	0.044	*0.064*
UO_2	0.0007	*0.0002*	0.0004	*0.0000*	0.0001	*0.0000*	0.0001	*0.0000*	0.0001	*0.0001*	0.0002	*0.0001*	0.0016	*0.0010*
ZrO_2/HfO_2	22	*3*	36	*1*	45	*2*	47	*3*	47	*3*	32	*3*	40	*4*
CaO/SrO	562	*139*	287	*2*	284	*44*	124	*18*	133	*33*	158	*8*	322	*60*

Fig. 5: Average concentrations for the main constituents of the different groups of glass. Average contents and standard deviation are expressed in weight %. © B. Gratuze.

copper, tin, antimony and lead may distort the levels of major elements, we have used the reduced compositions[21] when plotting together major elements or major elements with element ratios in figures 4 and 6, in order to reflect more accurately the compositions of the base glasses. For comparison with the most similar known Asian glasses, we have included in figure 5 the mean compositions of 56 mixed-alkali red and orange glasses found in South and Southeast Asia. Most of these were disk beads cut from a solid rod of glass and then individually perforated by drilling.

Groups 1 and 2: Natron and plant-ash soda glasses

We found in these two groups all of the 314 non-red, non-orange glasses (gr 1: 284, gr 2: 30), as well as 75 % of the opaque red samples (124 / gr 1: 71 and gr 2: 53) and 27 % of the opaque orange samples (13 / gr 1: 6 and gr 2: 7), showing the same range of compositions observed by Nenna and Gratuze.[22] While an important part of red, orange and green glasses was made with plant-ash soda glass, the other colours are mostly natron glass. We also observed the presence of high magnesia glass (primarily white) as reported by Nenna and Gratuze.

All these beads were probably fabricated using natron and/or plant-ash raw glass, or by re-melting older objects, as suggested by the presence of large numbers of tesserae and vessel fragments in the glass bead workshops at Ribe. Within groups 1 and 2 different sub-groups may be distinguished according to composition. These sub-groups appear to be due to recycling and mixing Roman and Late Roman glasses of slightly different compositions. Some variations may also be related to particular processes of colouring (addition of reducing agents or colourants of specific composition).

Group 3: low-alumina mixed-alkali red and orange glass

This group consists of red (3) and orange (12) glasses (14 entire beads and 1 red motif of a mosaic bead) coloured by copper. The glass is characterised by the use of a mixed soda-potash flux with similar contents of soda (3–6 wt %) and potash (3–5 wt %), with a low-alumina (<0.5 wt %) silica source, possibly crushed quartz pebbles or very pure sand. The colours come from cuprous oxide, with large red cuprite (Cu_2O) crystals observed in the red glass, and a mixture of small yellow and large red cuprite crystals in the orange glass. Copper concentrations range from 6 to 7 wt % in the red glass and 20 to 25 wt % in the orange glass. All the orange glasses and two of the red glasses are in the form of barrel-shaped or conical beads. The exception is a small red motif on a mosaic glass bead.

Group 4: high-alumina mixed-alkali red and orange glass

As for group 3, group 4 glasses are only opaque red (38) and orange (23), but in a broader range of typologies, as might be expected from the greater number of samples. For red glass, we have different types of barrel and spherical beads, a large variety of red motifs on mosaic glass beads, including the 8th century example from grave 46, Nørre Sandegård, shown in figure 3 (right, b), and the crucible glass from Norrbys, Gotland. Orange glasses are represented by barrel-shaped and spherical beads, along with the body of a 7th century polychrome bead from grave K2, Nørre Sandegård, figure 3 (right, a). From a chemical point of view, this glass is a mixed soda-potash glass characterised by high concentrations of alumina (> 8 wt %) and trace elements (cerium, thorium, uranium and zirconium). The red colour is from metallic copper, and the orange from a mixture of small and large cuprite crystals, as for the orange glass in group 3. Copper concentrations range from 1 to 5 wt % in the red glass and from 11 to 18 wt % in the orange glass. With the exception of the Byzantine glass vessels associated with Anatolia, discussed above, the only objects made with aluminous soda glass that have previously been found in the Western Mediterranean world are small Indo-Pacific glass

21 Brill 1999, 9.

22 Nenna and Gratuze 2009, 199–205.

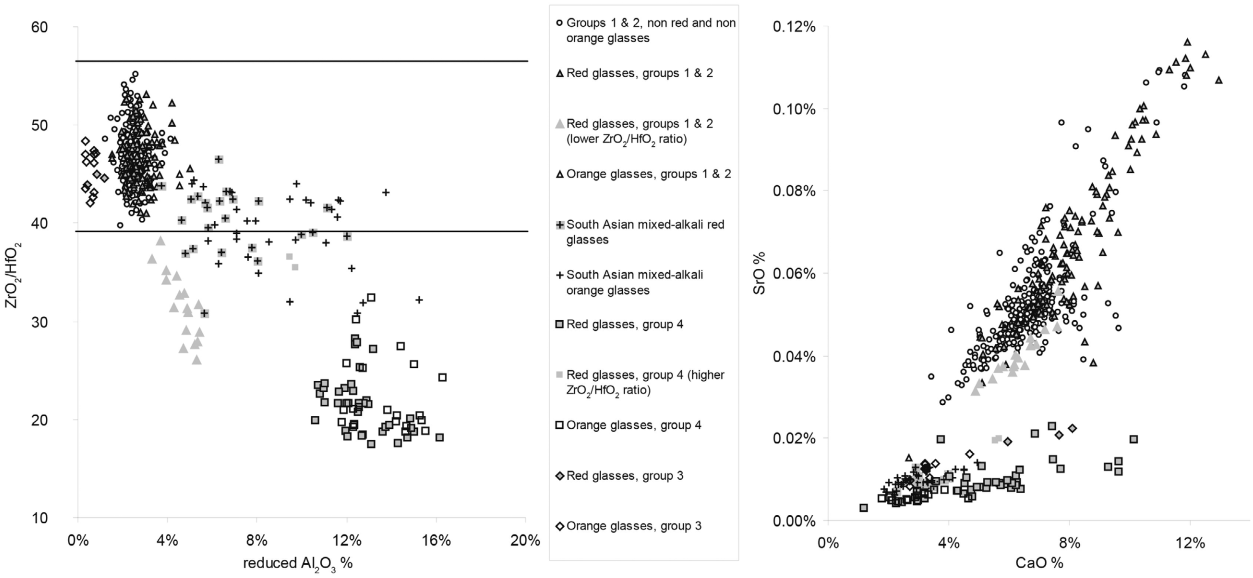


Fig. 6: Differentiation of glass groups according to their ZrO_2/HfO_2 ratio and reduced alumina content (left), and their SrO and CaO contents (right). © B. Gratuze.

beads recently identified in Merovingian (mid-5th to mid-6th century) Gaul.[23] Although group 4 appears more similar to mixed-alkali red and orange glass from South and South-East Asia,[24] than to the natron and plant-ash soda high-alumina glasses found in Anatolia, the trace element signatures remain different (figures 5 and 6). In particular, the ratio of zirconium to hafnium (ZrO_2/HfO_2, expressed as oxides) is approximately 22 for group 4 instead of 46 for groups 1, 2 and 3, and 40 for the mixed-alkali South and South-East Asian high-alumina glasses. On the other hand, the ratios of lime to strontium (CaO/SrO) for groups 3, 4 and the South Asian mixed-alkali glasses are much higher than those for groups 1 and 2.

Morphological examination

Figure 3 (left) shows seven representative barrel or conical beads from groups 1, 3 and 4 found in Scandinavia, along with one similar bead from Kaushambi, North India (from surface finds), believed to date from the Early Historic Period, approximately 1st century BCE to 4th century CE. Both macroscopically and microscopically, we were unable to find consistent morphologic differences between the red and orange beads of different compositional groups, or between the Scandinavian beads and that from Kaushambi. In addition, the red and orange beads from Vindinge, 200 years earlier than the appearance of compositional groups 3 and 4, appear to share many of the same technological characteristics. While some of the beads show circumferential strain marks indicating that they were made by winding hot glass around an iron rod or mandrel, others appear to be neither wound nor drawn. Instead, the hot glass, whether as fragments or as a pre-formed pad, may have been wrapped or folded around a mandrel, resulting in the partially fused seams apparent in several of the beads. The bead ends are invariably flattened, probably by grinding after the glass had cooled. For some of the beads, notably the cornerless cubes, the sides were finished by grinding as well. The mosaic beads incorporating elements of group 4 glass were indistinguishable from mosaic beads made only with the other types of glass (figure 3, right).

DISCUSSION

Our studies of glass beads from other sites in Scandinavia and western Germany confirmed our initial observation of high-alumina red and orange glass at Ribe, while expanding the distribution to 7th and 8th century contexts throughout the area. In answer to Archaeological Questions 1 and 2 (identification of the glass types and of their provenance), we found that at least four types of raw glass were used to produce opaque red and orange beads during this period, while only recycled Roman glass was used at earlier dates. Of the four types, at least group 4, and probably group 3, has a greater similarity to Asian glass than to glass produced in the Near East or Mediterranean area. However, even if the trace elements match with known South and Southeast Asian mixed-alkali high-alumina glass is not exact, our Asian reference corpus (mostly from unpublished data), for this type of glass is limited (32 orange and 24 red glasses) and consists mainly of earlier examples (1st century BCE to 4th century CE); further research and comparison samples will be important.

For Question 3, we wondered whether South Asian glasses (mainly group 4, but probably also group 3) were imported as raw glass or finished beads. This question turned out to be more difficult to answer than we anticipated. On one hand, the unusual technology for making the barrel and conical beads does not seem to differ between the beads found in Scandinavia and that found at Kaushambi, implying a possible Asian origin for the beads. On the other

23 Pion and Gratuze 2016, 51–64.
24 Dussubieux, Gratuze and Blet-Lemarquand 2010, 1646–1655; Dussubieux and Gratuze 2013, 399–414.
25 Ansson and Evgenij 1992, 74–83.

hand, many of the group 1 barrel beads, as well as earlier beads from Vindinge, appear to have been made by the same methods. These beads were almost certainly not made in Asia, where recycled Roman glass was quite rare. Is it possible that group 3 and 4 beads were imported, most likely from northern India, then copied in locally available glass? Based on the 4th century Vindinge dates, the technology for making these beads may already have been known in Scandinavia. Thus, it is perhaps more likely that raw type 3 and type 4 glass was imported into Scandinavia, to be made there into the beads found at our archaeological sites. The identical appearance of the beads made from type 1 and type 4 glass would be evidence for this, even though no actual large unworked chunks have been found. What is certain is that the Asian type 4, and probably type 3, glass, whether as unworked fragments or broken beads, was then incorporated into local workshops, with excellent evidence in the form of local or regional polychrome beads incorporating group 4 glass, shown in figure 3 (right), as well as the crucible fragments from Gotland. This is confirmed by the presence in groups 1 and 2 of 17 red glasses with lower ZrO_2/HfO_2 ratios (26 to 38 instead of 46) and in group 4 of two glasses with higher ZrO_2/HfO_2 ratios (36 instead of 22), as shown in figures 5 and 6. With chemical compositions intermediate between those of groups 1 and 2 and group 4, these glasses are most likely the result of mixing variable parts of glass from groups 1 and 2 and group 4, and were used as motifs on mosaic glass beads, as well as to make one monochrome conical bead, similar in typology to some of the red and orange glass beads from group 3.

How did this Asian glass reach Scandinavia? So far, northern India seems the most likely source for the group 3 and group 4 mixed-alkali glasses. The trade could have been to the north and east through Tokharistan and Sogdia toward the Caspian Sea, then via the Russian river systems to Scandinavia, routes that became increasingly important during the Viking period beginning in the late 8th century.[25] Exchange along more traditional Silk Routes through northern Iran would also have been possible. The apparent lack of similar Asian glasses in most of the rest of Europe suggests that trade may have been relatively direct to Scandinavia rather than through southern Europe. The presence of cowries, beads of Indo-Pacific shells, amethyst beads and bronze jewellery inlaid with Indian garnets in the same contexts as red and orange barrel beads, as well as the Buddha stature from Helgö, shows that objects from the Indian subcontinent did reach Scandinavia as early as the 7th century, most likely along similar trade routes. A range of garnet-bearing objects from the collections of the Statens Historiska Museet in Stockholm has recently been analyzed within the project ‘international framework’ in the laboratories of the Roemisch-Germanisches Zentralmuseum in Mainz. The unpublished results indicate that most of the garnet inlays come from occurrences in India and Sri Lanka (pers. comm. S. Greiff).

CONCLUSIONS

By combining traditional morphological and technological studies with quantitative chemical analysis, including trace elements, we have uncovered the presence of an unexpected and important group of Asian glasses in 7th and 8th century Scandinavia and northern Germany. This unequivocal evidence for long-distance exchange now challenges us to explore both more precise production zones and a better understanding of how this exotic glass reached Scandinavia. In addition, our evidence for the use and re-use of Asian glass, combined with recycled Roman glass, in local workshops in Denmark (Ribe) and Sweden (Gotland) increases our understanding of how beadmakers practiced their craft in an increasingly internationalized context leading up to the Viking period.

REFERENCES

Andersen, Jan and Sode, Torben, 2012. ‘The Glass Bead Material’. In: *Ribe Excavations 1970–76*, Aarhus.

Becker, Carl J., 1955. ‘Smykkefundet fra Ørby. Et glimt fra Sjællands glemte storhedstid’, *Fra Nationalmuseets Arbejdsmark,* København, 26–34.

Brill, Robert H., 1999. *Chemical Analyses of Early Glasses.* Vol 2, Corning.

Calligaro, Thomas and Périn, Patrick, 2013. ‘Route des grenats 3, Inde, Tamil Nadu, août 2013: note sur l’origine géologique des grenats utilisés par les orfèvres du haut Moyen Âge occidental’, *Bulletin de liaison de l’Association française d’Archéologie mérovingienne* 37, 125–131.

Callmer, Johan, 1997. ‘Beads and bead production in Scandinavia and the Baltic Region c. AD 600-1100: a general outline’. In: Freeden, Uta von and Wieczorek, Alfried (eds.), *Perlen. Archäologie, Techniken, Analysen*, Bonn, 197–201.

Degryse, Patrick (ed.), 2014. *Glass Making in the Greco-Roman World: Results of the ARCHGLASS Project*. Leuven.

Dussubieux, Laure and Gratuze, Bernard, 2013. ‘Glass in South Asia’. In: Janssens, Koen H. A. (ed.), *Modern Methods for Analysing Archaeological and Historical Glass*. Chichester, 399–414.

Dussubieux, Laure, Gratuze, Bernard and Blet-Lemarquand, Maryse, 2010. ‘Mineral soda alumina glass: occurrence and meaning’, *Journal of Archaeological Science* 37.7, 1646–1655.

Foy, Danièle and Picon, Maurice, 2005. ‘L’origine du verre en Méditerranée occidentale à la fin de l’Antiquité et dans le haut Moyen Âge’. In: Delestre, Xaxier, Périn, Patrick and Kazanski, Michel (eds.), *La Méditerranée et le monde mérovingien : témoins archéologiques.* Actes des XXIII^{e} Journées internationales d’archéologie mérovingienne. 11–13 octobre 2002 Arles. Bulletin archéologique de Provence, Supplément 3. Aix-en-Provence, 99–110.

Francis Jr., Peter, 2002. *Asia’s Maritime Bead Trade, 300 B.C. to the Present.* Honolulu.

Freestone, Ian C., Gorin-Rosen, Yael and Hughes, Michael J., 2000. 'Primary glass from Israel and the production of glass in late Antiquity and the early Islamic period'. In: Nenna, Marie-Dominique (ed.), *La route du verre: ateliers primaires et secondaires de verriers du second millénaire av. J.-C. au Moyen-Age*. Travaux de la Maison de l'Orient Méditerranéen, 33. Lyon, 65–83.

Freestone, Ian C., 2000. 'Glass production in late Antiquity and the Early Islamic Period: a geochemical perspective', *Geological Society, London, Special Publications* 2006. 257, 201–216.

Gratuze, Bernard, 2013. 'Glass characterisation using laser ablation inductively coupled plasma mass spectrometry methods'. In: Janssens, Koen H. A. (ed.), *Modern Methods for Analysing Archaeological and Historical Glass*. Chichester, 201–234.

Hansen, Ulla L., 2011. 'New analyses of the Helgö drinking-glass fragments'. In: Arrhenius, Birgit and O'Meandhra, Uaininn (eds.), *Excavations at Helgö XVIII*, Stockholm, 97–139.

Iversen, Mette and Näsman, Ulf, 1978. 'Smykkefundet fra Eketorp-II'. In: Kjærum, Poul (ed.), *Kulm 1977*. Copenhagen, 85–104.

Jansson, Ingmar with a contribution by Nosov, Evgenij N., 1992. 'The way to the East'. In: Roesdahl, Else and Wilson, David M. (eds.), *From Viking to Crusader. The Scandinavian and Europe 800–1000*. Copenhagen, 74–83.

Jørgensen, Lars and Jørgensen, Anne N., 1997. *Nørre Sandegård Vest. A Cemetery from the 6th–8th Centuries on Bornholm*. Copenhagen.

Lankton, James and Dussubieux, Laure, 2013. 'Early glass in Southeast Asia'. In: Janssens, Koen H. A. (ed.), *Modern Methods for Analysing Archaeological and Historical Glass,* Chichester, 415–444.

Lamm, Kristina, 2008. 'Crucibles and cupels from Building Group 3'. In: *Excavations at Helgö XVII*. Stockholm, 171–208.

Ljungkvist, John, 2010. 'Influence from the Empire: Byzantine-related objects in Sweden and Scandinavia – 560/570–750/800 AD'. In: Daim, Falko and Drauschke, Jörg (eds.), *Byzanz – das Römerreich im Mittelalter*, Mainz, 419–441.

Lundström, Agneta, 1981. 'Survey of the glass from Helgö'. In: *Excavations at Helgö VII*, Stockholm, 1–38.

Pion, Constantin and Gratuze, Bernard, 2016. 'Indo-Pacific glass beads from the Indian subcontinent in Early Merovingian graves (5th–6th century AD)', *Archaeological Research in Asia* 6, 51–64.

Nenna, Marie-Dominique and Gratuze, Bernard, 2009. 'Étude diachronique de compositions de verres employés dans les vases mosaïqués antiques : résultats préliminaires.' In: Janssens, Koen, Degryse, Patrick, Cosyns, Peter, Caen, Joost and Van't Dack, Luc (eds.), *Annales du 17e Congrès de l'AIHV. Annales of the 17th Congress of the AIHV. Anvers 2006*. Brussels, 8–14.

Nerman, Birger, 1951. 'Degel från Gotlands Vendeltid för tillverkning av glasflusspärlor', *Fornvännen. Journal of Swedish Antiquarian Research*, 252–253.

Nielsen, Karen H., 1987. 'Chronologie der Jüngeren Germanischen Eisenzeit auf Bornholm. Untersuchungen zu Schmuckgarnituren', *Acta Archaeologica S* 7, 47–86.

Östergreen, Majvor, 1989. *Mellan stengrund och stenhus*. Theses and Papers in Archaeology 2. Stockholm.

Rehren, Thilo, Connolly, Philip, Schibille, Nadine and Schwarzer, Holger, 2015. 'Changes in glass consumption in Pergamon (Turkey) from Hellenistic to late Byzantine and Islamic times', *Journal of Archaeological Science* 55, 266–279.

Rehren, Thilo, Marii, Fatma, Schibille, Nadine, Swann, Carolyn and Stanford, Lucy, 2010. 'Glass supply and circulation in early Byzantine southern Jordan'. In: Drauschke, Jörg and Keller, Daniel (eds.), *Glass in Byzantium – Production, Usage, Analyses*. RGZM-Tagungen 8. Mainz, 65–81.

Schibille, Nadine, 2011. 'Late Byzantine mineral soda high alumina glasses from Asia Minor: A new primary glass production group' [Online], *PloS ONE* 6.4. Available at: doi:10.1371/journal.pone.0018970 (20th December 2016).

Shortland, Andrew J., Schachner, Lucas, Freestone, Ian and Tite, Michael, 2006. 'Natron as a flux in the early vitreous materials industry: sources, beginnings and reasons for decline', *Journal of Archaeological Science* 33, 521–530.

Sode, Torben, Feveille, Claus and Schnell, Ulrich, 2010. 'An investigation on segmented, metal-foiled glass beads and blown, mirrored glass beads from Ribe.' In: Theune, Claudia (ed.), *Zwischen Fjorden und Steppe. Festschrift für Johan Callmer zum 65. Geburtstag*. Rahden/Westfald, 319–328.

Torben Sode
sode@mail.dk

Bernard Gratuze
IRAMAT-CEB
CNRS/Univ Orléans
gratuze@cnrs-orleans.fr

James W. Lankton
UCL Qatar
jamesyuri@gmail.com