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An investigation on segmented, metal-foiled glass beads and blown, mirrored glass beads from Ribe, Denmark

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The glass bead material from Ribe is unique in terms of the large number of imported and locally made beads, semi-finished beads, raw materials and production waste uncovered here, and also because of the presence of tools and the remains of workshops, which can be related to a local domestic production of glass beads (Bencard 1979; Bencard et al. 1990; Feveile 2010; Sode 2001; Sode 2004). The context of the finds from the excavations at Ribe allowed a classification of the archaeological material into a number of phases, which have been subsequently dated very precisely (Feveile/Jensen 2000). The market-place in Ribe was established just after the year 700 AD and functioned with one or more seasonal markets every year until around 780 AD. The market-place then changed in character, as some individual plots revealed evidence of a permanent settlement, indicating that, at the very latest, from this point of time we can expect a continuous presence of craftsmen and traders. In the mid 9th century – or maybe a little later – the vigorous growth of archaeological layers on the market-place comes to an end and finds and features dating to the following 150–200 years are almost absent (Feveile, C. 2006b).

Glass beadmakers were among the first craftsmen to establish workshops in Ribe. There are numerous finds up to the end of the 8th century, which can be related to this local production of glass beads; but the later phases also contain finds, indicating local glass bead manufacturing. Apart from the local glass beads, the bead material also contains imported beads. In all 18 568 pieces of glass have been excavated in Ribe (Feveile, C. 2006a, Pl. 1) consisting of 4 998 whole or fragmentary glass beads; 7 546 glass pieces from bead production, both semi-manufactured and raw glass; 4 063 glass tesserae – small cube formed glass pieces in different colours[1] – as well as 2 970 pieces of hollow glass fragments from drinking glasses, bowls, funnel beakers, palm-cups and other pieces of blown glass (Feveile, L. L. 2006); all seemingly of Frankish origin. Further 238 pieces of glass were registered as diverse glass.

The finds from the earliest phase of the market-place in Ribe show, that until around 725 AD the beadmakers produced mainly plain coloured, transparent blue or opaque white glass beads. The bead material changes character around 725 AD and the following 40 years are often referred to as the 'blue period' in a southern Scandinavian bead context (Callmer 2007). The plain coloured glass beads are dominated during this period by transparent dark blue beads. Furthermore, dark blue beads occur in large numbers with mono- and polychrome thread decorations in a number of variations. The beadmakers in Ribe also produced different forms of mosaic beads with chequer board patterns as well as the so-called reticella beads, a blue bead type made of multi-coloured twisted glass threads. It is these locally produced blue plain and multi-coloured glass beads, which are often given the popular name "Ribe beads". Just after the mid 8th century new types of beads appeared. Monochrome wound cylinder beads, generally a little smaller in size and generally in a opaque red brown or green colours occur. The 'wasp beads' begin to appear simultaneously. A typical wasp bead is constructed like a black cylinder bead with three parallel molten opaque yellow glass threads in relief. Wasp beads are also found in a number of variations with opaque red brown, transparent green or blue glass with different variations of applied thread decoration.

At the end of the 8th century the bead material yet again changes character and is dominated hereafter by bead types most probably imported from the Near-Eastern area (Fig. 1). The mosaic eye beads (Andrae 1975), which often are found together with segmented metal-foiled glass beads, appear in the records from Ribe from phase F onwards at the latest.[2] Furthermore another specific type which also occurs is the green, drawn and often five- or six-sided bead. These beads, which are characterized by a very high lead content (Steppuhn 1997), are found from phase E and onwards with an emphasis on phases F and G. These beads also most probably originate from the Near-East (ibid.). Finally, in phases G and H/I there is a higher representation of the beads produced from drawn glass tubes, subsequently cut off in small cylindrical pieces which were then reheated and melted round (Sode 2003). The majority of the drawn glass tube beads are small round beads with a diameter of 4–6 mm, with a weight varying between 0.04 and 0.08 grams per piece. This would mean that on average there would have been around 20 000 glass beads to the kilo. The largest drawn beads have a diameter of between 6 and 10 mm and can be described as off-cuts, short and cylindri-

[1] Analyses made by Dr. Robert Brill, Corning Museum of Glass (Brill 1999), show that that the chemical composition of the tesserae indicates Italian rather than Byzantine origin. Tesserae produced in Italy after the 4th century are mainly made of high magnesium and high calcium glass. Byzantine tesserae are made of high magnesium and low calcium glass. In Byzantine glass tin oxide was used as an opacifer while in the Italian glass antimony is normally used.

[2] Phase divisions are based on the stratigraphy of the ASR9 Post-Office excavation: Feveile/Jensen 2000; Feveile, C. 2006a.

Fig. 1. A selection of glass beads from Ribe. a) Segmented without metal foil. b) Segmented metal foiled. c) Blown mirrored beads. d) Green faceted high lead beads. e) Drawn glass tube beads. f) Mosaic eye beads.

cal in form. They are often unevenly cut off and the edges are never rounded off in the same manner as the smaller drawn beads. These drawn glass tube beads are in general interpreted to have been produced in the Near East.

Apart from the afore mentioned imported glass beads which are interpreted to be manufactured in early Islamic glass workshops, segmented metal-foiled glass beads also occur in great number and numerous types from phase E onwards; with the majority of them found in the phases F and G. Glass beads probably manufactured in early Islamic glass workshops occur often in the archaeological records in Europe, the Middle and Far East as well as North and West Africa from the end of the 8th century and in the following centuries. The production and trading of these glass beads, produced in glass centres in the Near East, seems to have been controlled by Arabic merchants during this period, supplying large parts of the known world, either directly or through middlemen. In order to obtain a better understanding of the peoples with whom they traded, the Arabic sultans and caliphs sent geographers together with their trade ships. These geographers were to map the unknown areas, and also to describe the inhabitants of these regions. It was on one such trade journey, that the Arabic geographer Ibn Fadlan in 922 met and experienced the Vikings on the Volga at first hand and described the burial rites of a Viking chieftain there. The first part of Ibn Fadlans account was a general description of the Vikings and their way of life, trade etc. He recounts that beads were highly valued by the Vikings and that beads were transported on the trade ships (Simonsen 1981).

Segmented metal-foiled glass beads

Glass beads manufactured with a thin piece of gold foil between two layers of glass are known back to the Hellenistic period. The earliest gold foil beads have both figurative, star or melon and segmented designs (Spaer 2001). Silver-foiled beads first appear during the Ro-

	Segmented metal foiled glass beads with amber colered outer glass												Segmented metal foiled glass beads with clear outer glass											Segmented metal foiled glass beads with blue outer glass					Total
	1 seg half	1 seg complete	2 seg half	2 seg complete	3 seg half	3 seg complete	4 seg half	4 seg complete	7 seg complete	Fragments	Collarbead	No information	1 seg half	1 seg complete	2 seg half	2 seg complete	3 seg half	3 seg complete	4 seg complete	5 seg half	6 seg complete	Collarbead	No information	1 seg half	1 seg complete	3 seg complete	4 seg complete	No information	
Ribe excavations 1970-76											1	7											3						11
ASR 8 Rosenallé												1																	1
ASR 926 Ribelund I						1																							1
ASR 1085 Gasværksgrunden																										1			1
ASR 7 Sct. Nicolajgade 8												8																	8
ASR 9 Post Office	24	38	14	31	3	10		5		13		4	1	3	1	5	2	2	1	1		3	5		1	1		1	169
ASR 1077 Sct. Nicolajgade 14	4		1				1			3		1	1					1											12
ASR 951 Riberhus		1																											1
ASR 1357 Giørtzvej	16	28	5	15	2	5		5	1	10			2	2	1		1	2			1			1	1		1		99
Total	44	67	20	46	5	16	1	10	1	26	1	21	4	5	2	5	3	5	1	1	1	3	8	1	2	2	1	1	303
												258											38					7	

Fig. 2. Segmented metal foiled glass beads from different excavations in Ribe. Within each of the three kinds of colours in the outer glass the beads are divided into a number of segments, just as it appears whether the beads are in halves (normally split lengthwise cf. some examples on Fig. 1b) or intact.

man Iron Age with a thin layer of silver foil beneath a transparent clear or amber coloured outer glass. The metal foils of both the gold and silver beads gave them a somewhat metallic appearance. Gold and silver-foiled beads remained a stable uniform bead type throughout antiquity which had not changed much through time. They were probably a mass produced bead type, imitating real gold or silver beads. The metal-foiled glass beads are described in the archaeological literature under many different names, such as gold and silver foil beads, gold-glass beads, sandwich gold glass beads, gold in glass beads and metal-foiled beads (Spaer 1993).

In the 6th and 7th centuries gold and silver-foiled beads largely disappear from the Scandinavian region, whilst these beads continue to be common and prevalent in the Near East and Russia and especially in the areas around the Black Sea. At the end of the 8th century segmented metal-foiled glass beads appear all over Europe. In contrast to the earlier gold foil beads of the Hellenistic and Roman Iron Age, solely silver foil is now used in the production of metal-foiled glass beads. The employment of a transparent amber coloured glass in the outer glass gives the impression of a gold bead, whilst the use of a transparent clear glass makes the beads resemble silver beads. A further type utilized a transparent blue outer glass, giving the bead the appearance of a metallic blue segmented bead. The majority of the segmented metal-foiled glass beads have an amber coloured outer glass. Often only a small part of the inner glass core is covered by silver foil and a number of beads lack the foil entirely. This has resulted in the term "false gold foil beads" which sometime can be encountered in the literature on the subject (Francis 2002, 93).

Excavations from the market-place in Ribe have resulted in the finds of in all 258 segmented metal-foiled glass beads with amber coloured outer glass, 38 beads with a clear outer glass and seven with a transparent blue outer glass (Fig. 2). As evident in the phase classifications of the Post-office excavation, segmented metal-foiled glass beads are found in the same phases as the blown mirrored glass beads, faceted green lead glass beads and mosaic eye beads (Fig. 3). The same phase also contains the closely related monochrome segmented beads. These bead types are primarily composed of transparent dark blue beads, manufactured from a single layer of glass, as well as blue beads with white stripes parallel to the bead hole. The Post-Office excavation also unearthed one segmented yellow bead consisting of five segments. The segmented metal-foiled glass beads are often almost round beads; in all 123 beads consist of only one segment, but the beads also occur with two, three or more segments. Amongst the entire bead material from Ribe, only one specimen has seven segments. Examples of beads with both ten and more segments are known from Central and Eastern Europe (Steppuhn 1998, 31; Zoll-Adamikowa et al. 1999). The bead material from Ribe also includes four so-called collar beads – three with a clear outer glass and one with an amber coloured outer glass. Collar beads are composed of an oval centre segment with

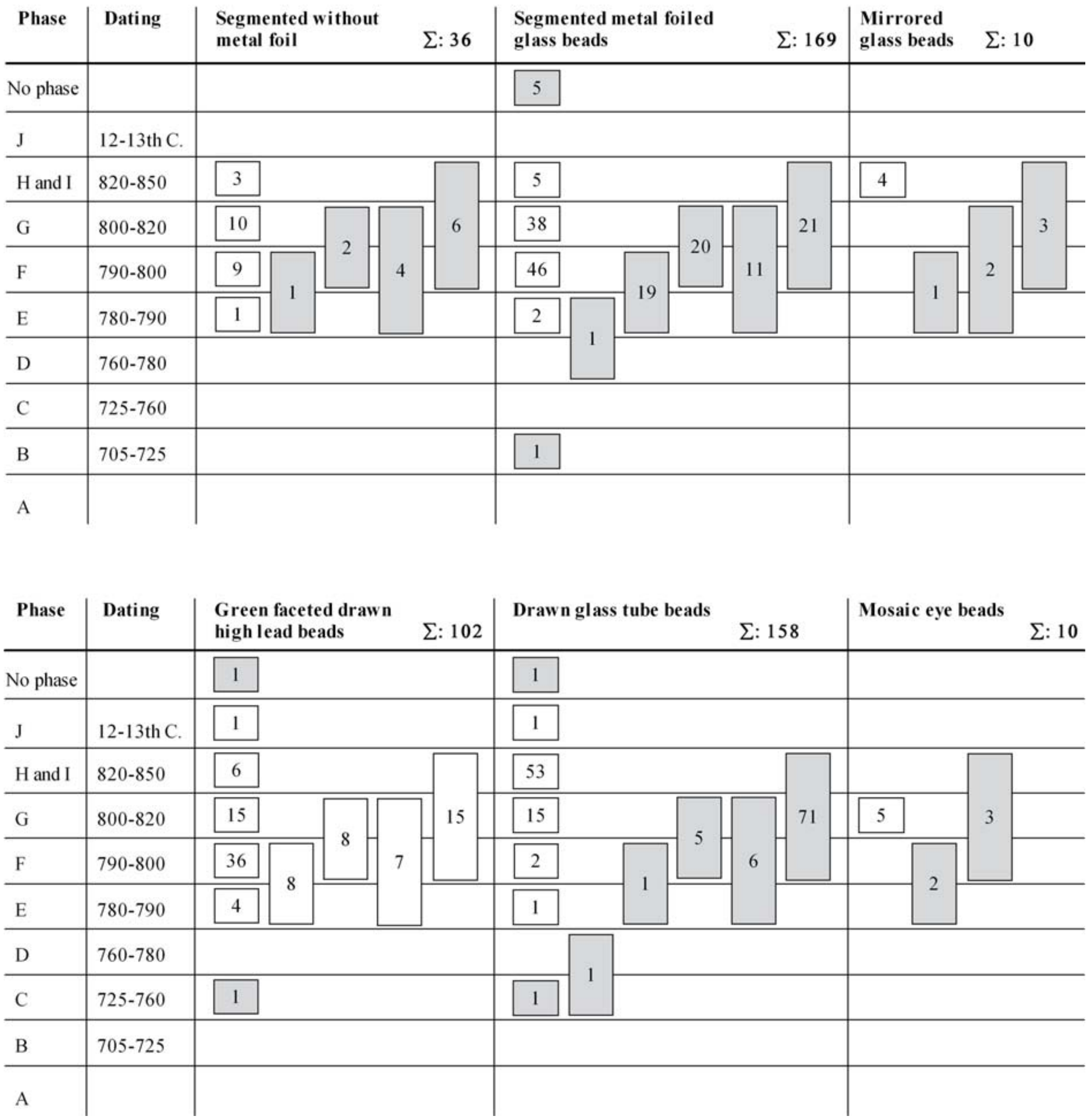

Fig. 3. Review of a number of imported bead types from the ASR 9 Post-Office excavation divided into number of beads per phase. White spaces give the number of beads that can be related to one phase, while the grey spaces give the number of beads that can be related to two or more phases as well as beads where the belonging to the phase is considered mistaken.

a disc-shaped segment on each side (Fig. 1b top left). The segmented beads from Ribe vary in both form and size. The individual segments can either be sphere, oval, ring formed or approximately cylindrical. The diameter is in most cases between 4–6 mm, but can vary from between 2½ and 11 mm.

The segmented metal-foiled glass beads seem to have been manufactured by pre-fabricating an inner core and an outer tube separately. A piece of silver foil had been rolled around the inner core, which thereafter is placed inside the outer tube. The very distinct straight edges of the silver foil indicate that the foil was placed between the two layers of glass in cold conditions (Fig. 4, top). The inner core was made of uncoloured glass, filled with elongated air-bubbles, which give a lengthwise structure parallel with the bead hole. Due to the many long drawn air-bubbles the glass appears, in regard to light refraction, as a light grey opaque glass with a somewhat milky appearance (Fig. 4, bottom). The outer glass was made as a thin walled glass tube, likewise with long drawn oval shaped air blains. The compounded glass tubes were mounted on an iron mandrel and then warmed up and rolled over a grooved stone form. The individual segments are then, after cooling,

Fig. 4. Segmented metal foiled glass bead. Top: The edge of the silver foil is clearly visible under the amber coloured outer glass. Bottom: The same bead cut through. The construction of the bead can clearly be seen, with inner and outer glass, as well as the variation in the diameter of the bead hole. Length: 21 mm.

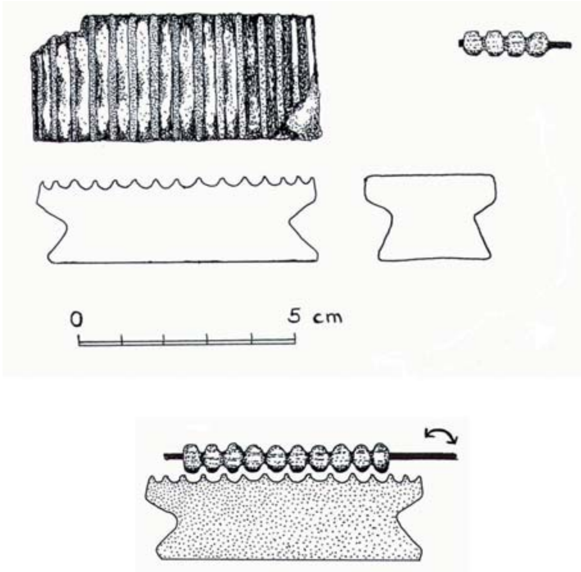

Fig. 5. Grooved stone mould and a segmented glass bead fastened on a iron wire (after Rodziewicz 1984). At bottom, a reconstruction of the production of a segmented glass bead.

broken off as separate beads or as beads composed of a number of segments, and the broken off terminals can often be recognized as a sharp edge around the bead hole. During the manufacturing process the silver foil is often burnt onto the outer glass, which is possibly the reason why the metal is always missing from the places where the outer glass has been broken off. In some cases there has been too much air between the two layers of glass, and small pockets of air had developed between the outer and the inner glass on the finished bead. This can be observed on a number of instances of beads from Ribe.

The stone moulds used in the production of different segmented glass beads were recovered from the excavation of a glass bead workshop in Kom el Dikka in Alexandria (Rodziewicz 1984; Fig. 5). Kom el Dikka is dated to between the 4th and the early 7th century and is therefore somewhat older than the bead material from Ribe, but the find clearly illustrates how the segmented glass beads could have been produced. There are no metal-foiled beads from the Alexandria excavations, only monochrome segmented glass beads. One bead was found burnt onto the iron mandrel, which had been used, when heating and forming the segmented glass beads on the grooved stone forms. The presence of the iron mandrel explains the uneven structure, which can be seen in the perforation of the segmented beads. This can be clearly seen on the broken beads, where the lengthwise bead hole has a uniform diameter through the entire bead, but exhibits an expansion of the bead hole in the middle of each segment.

A number of failed beads of a very irregular form are found among the segmented metal-foiled glass beads, just as a large number of beads have a defect or incomplete bead hole. The same is true of beads from Kaupang in Norway, Ladoga in Russia[3] and Haithabu in Germany (Steppuhn 1998, 26). Peter Francis jr. carried out similar research with finds from the excavation of Takua Pa in Thailand, where they also observed metal-foiled glass beads lacking a complete bead hole. This was interpreted as representing a local production of segmented metal-foiled glass beads (Francis 2002, 93). It may be more likely to assume, that the many finds of defective metal-foiled glass beads in different trade centres is due to the purchasing of the beads in loose weight at their place of manufacturing and their subsequent trade as loose beads – which are then first sorted at the market-place of the port of call; prior to selling them on (Sode/Feveile 2002, 5).

Blown mirrored glass beads

A closely related bead type to the metal-foiled glass beads are blown mirrored glass beads, coated inside with lead (see Fig. 1c). The metal can be clearly distinguished as a grainy dark grey coating on the fragmented beads. Eight fragments of this type of beads were recovered from the Post-Office excavation in Ribe, made of transparent amber coloured glass, thus belying the appearance of gold beads, as well as one whole oval bead made of clear glass – just like a silver bead made of mirror glass. In a later excavation from Kunstmuseet a small round green mirrored glass bead was found. These beads occur in Ribe from phase F and onwards (see Fig. 3). This type of bead is rarely seen amongst the Scandinavian finds, apart from the

[3] Unn Pedersen, Oslo University, pers. comm. See also Rjabinin/Galibin 1995.

excavations of Haithabu, where 825 examples of this bead type have been found – made of clear, transparent amber coloured or blue glass and in varying sizes and shapes (Steppuhn 1998, 39 f.).
The blown, mirrored beads were produced using a transparent glass with a number of small round or lens formed air-bubbles. The beads were probably manufactured using glass tubes, subsequently heated up and shaped into the final design. The round and pronounced edges around the bead holes indicate that the beads were hot shaped.
The manufacturing of the blown, mirrored lead coated glass beads seems to be closely related to the ancient production of lead-coated glass mirrors. Pliny the Elder wrote that glass mirrors were invented in Sidon, situated in present-day Lebanon. From the Viking Age lead-coated glass mirrors are known from the large cemetery at Birka, Sweden, from the Viking fortress of Fyrkat, Denmark and from the trading centre Haithabu in Schleswig, Germany (Kock/Sode 2002).

Analyses

Seven glass beads were selected for Lead Isotope analyses (LI). The LI analyses were performed on a VG 54-IT mass spectrometer by Thermal Ionisation Mass Spectrometry (TIMS; Tab. 2).[4] 13 beads were selected for elemental analysis (Tab. 1) by Scanning Electron Microscopy and Energy Dispersive Spectrometry (SEM). The SEM analyses were performed using a JEOL LV 5310 at the School of Conservation, Copenhagen (Tab. 3 and 4).[5]
The interior metal from three fragments of blown, mirrored glass beads made of amber brown glass (sample A–C) and one intact blown, mirrored glass bead with clear glass (sample D) were together with one half green hexagonal high lead glass bead (sample E) from the Post-Office excavation, Ribe (ASR 9; Feveile, C. 2006a) analyzed by TIMS to measure the lead isotope ratios. Two of these (A and B) were also analyzed by SEM for their elemental compositions.
Five segmented metal-foiled glass beads (sample 3 to 7) and one fragment of a blown, mirrored glass bead (sample 2) from the Giørtzvej excavation, Ribe (ASR 1357; Feveile, C. 2006a) were also analyzed using SEM to find out the composition on the glass, the coated metal from the inside of the blown bead and the metal foil used in the segmented beads. In order to be able to make comparative analyses on the lead from the inside of the blown, mirrored beads, we were kindly given permission from the Verein zur Förderung des Archäologischen Landesmuseums, Schloss Gottorf, Schleswig, to take samples from two blown mirrored beads from the Haithabu excavations (sample 8 and 9).

Interpretation of the results of lead isolope analysis

The lead present in glass and metal (lead, copper and silver, for example) originates from minerals used in the production of these materials. This lead has a characteristic isotope composition that can be traced to the original mineral deposit from which the ore was derived (Gale/Stos-Gale 2000). The results of lead isotope analyses of the glass beads were interpreted by Dr. Zofia Anna Stos-Gale, formerly Director of the Isotrace Laboratory, University of Oxford, UK, using the Oxford lead isotope database (OXALID; Stos 2009, 164 f.).
The lead isotope data for the glass beads discussed in this paper are listed in Tab. 2. The comparisons of these data with the OXALID database show that no northern European ores analysed so far have lead isotope ratios consistent with these beads. The seven analysed beads have rather varied lead isotope ratios which indicate that the lead used in their production might have originated from various sources. The amber coloured hollow bead C has a lead isotope composition identical with some Spanish Andalusian ores (Stos-Gale et al. 1995). This, however, does not necessary mean that the glass was made in the Western Mediterranean – it is quite possible that lead from the Arabic Spain was being brought to the Near East either as raw material, or as anchors or ballast. The clear bead D has isotope compositions that could also be consistent with some Spanish ores, but more likely perhaps it is indicative of the lead ores from the Taurus Mountains in Southern Turkey (Yener et al. 1991). The green hexagonal bead E also contains lead that might have originated from the Taurus Mountains ores. The lead isotope ratios measured for the beads B, E and 8 are fully consistent with some silver pieces from the silver hoards from Akko/Ekron dated to the 7th century AD and also the silver hoard from Tell Ajjul, both in modern Israel. The geographical source of this silver is presently unknown, but according to Dr. Stos-Gale it might have been available on the Assyrian territory (Eastern Turkey or Iran). The analysed beads contain lead from different mines/occurrences mainly in the Near East. There is no apparent correlation between the type of bead and the isotope signature of the material used. None of the beads seems to contain lead from the Northern or Central European ore deposits for which there is lead isotope data. In antiquity lead and silver ores are associated and both metals were extracted most often from the same ores. Important silver mines were usually exploited continuously in different periods since the Bronze Age producing both metals. It is likely that the lead isotope ratios of these glass beads indicate that the lead used for making them was from the various lead metal circulating in the area in the triangle Caspian Sea – Persian Gulf – Eastern Mediterranean.
Samples A (Ribe) and 9 (Haithabu), both blown, mirrored glass beads, have nearly identical lead isotope compositions within the analytical error, so it is possi-

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[4] The LI analyses were kindly performed by Dr. Robert Frey at the Museum of Geology in Copenhagen.
[5] The analyses were performed by Cand. Scien. Ulrich Schnell, formerly National Museum of Denmark.

Sample	Inv. no.	Type
A	ASR 9 x363a	Fragment of blown, mirrored glass bead, amber colored glass
B	ASR 9 x363b	Fragment of blown mirrored glass bead, amber colored glass
C	ASR 9 x363c	Fragment of blown mirrored glass bead, amber colored glass
D	ASR 9 x363d	Blown mirrored glass bead , clear colored glass
1	ASR 9 x104	Green faceted high lead glass bead, half
2	ASR 1357 x205	Fragment of blown mirrored glass bead, amber colored glass.
3	ASR 1357 x35	Segmented metal foiled glass bead, one segment, amber colored outer glass
4	ASR 1357 x267	Segmented metal foiled glass bead, one segment, amber colored outer glass
5	ASR 1357 x123	Segmented metal foiled glass bead, one segment, amber colored outer glass
6	ASR 1357 x13	Segmented metal foiled glass bead, four segments, transparent metallic blue outer glass
7	ASR 1357 x374	Segmented metal foiled glass bead, one segment, clear outer glass
8	Haithabu 05591	Blown mirrored glass bead, amber colored glass
9	Haithabu 06127	Blown mirrored glass bead, amber colored glass

Tab. 1. List of analyzed beads.

Sample	Description	208Pb/206Pb	207Pb/206Pb	206Pb/204Pb	LI origin
A	Fragment of blown, mirrored glass bead, amber colored glass	2.08060	0.83480	18.993	Iran ?
B	Fragment of blown, mirrored glass bead, amber colored glass	2.07150	0.83290	18.915	Iran ?
C	Fragment of blown, mirrored glass bead, amber colored glass	2.10710	0.85970	18.323	Spain
D	Blown, mirrored glass bead, amber colored glass	2.08990	0.84180	18.713	Spain, or Taurus, Southern Turkey
E	Green faceted glass bead, half bead	2.06990	0.83100	18.919	Iran ?
8	Blown, mirrored glass bead, amber colored glass	2.06980	0.83260	18.899	Iran ?
9	Blown, mirrored glass bead, amber colored glass	2.07740	0.83510	18.926	Iran ?

Tab. 2. Results of lead isotope analyses of the glass beads from Ribe
(TIMS analyses by Dr. Robert Frey, interpretation by Dr. Z.A. Stos-Gale).

	Sample 3	+/-	Sample 4	+/-	Sample 6	+/-	Sample 7	+/-	Sample B	+/-
Cu wt%	2.19	0.022	0.15	0.288	0.47	0.246	0.68	0.184	0.33	0.078
Ag wt%	63.91	3952	92.68	0.352	96.12	0.94	95.43	0.228	-	-
Sn wt%	-	-	0.58	0.464	0.50	0.426	0.38	0.46	-	-
Sb wt%	33.90	0.446	6.58	0.408	2.91	0.826	3.51	0.322	5.806	0.992
Pb wt%	-	-	0	0.24	-	-	0	0.344	93.8576	0.15

Tab. 3. SEM chemical analyses of metal foil and coating.

	2	+/-	3 inner glass	+/-	3 outer glass	+/-	4 inner glass	+/-	4 outer glass	+/-	5 inner glass	+/-	5 outer glass	+/-	6 inner glass	+/-
O wt%	50.88	1.88	54.586	2.168	54.042	0.892	51.692	0.49	50.652	4.366	52.8	1.866	55.946	0.602	54.932	1.272
Na wt%	1.678	0.482	4.558	0.36	5.038	0.604	6.998	0.378	4.898	0.472	2.742	1.3	4.624	0.35	3.43	0.388
Mg wt%	3.196	0.15	3.006	0.42	2.82	0.092	2.632	0.134	3.104	0.342	2.578	0.174	2.546	0.06	2.584	0.08
Al wt%	0.664	0.026	0.808	0.32	0.7	0.014	0.992	0.044	0.7	0.158	0.782	0.062	0.888	0.016	0.64	0.028
Si wt%	33.43	1.206	29.81	1.206	30.30	0.63	29.39	0.326	32.05	3.27	31.79	1.314	29.08	0.548	31.15	0.86
S wt%	0.416	0.064	0.214	0.07	0.196	0.022	0.16	0.02	0.172	0.03	0.19	0.014	0.2	0.014	0.332	0.016
Cl wt%	0.71	0.046	0.598	0.128	0.596	0.018	0.626	0.026	0.636	0.156	0.638	0.148	0.588	0.03	0.454	0.03
K wt%	2.54	0.262	1.954	0.29	2.044	0.042	2.006	0.06	2.584	0.442	2.628	0.292	1.848	0.132	1.992	0.1
Ca wt%	5.216	0.724	3.52	0.326	3.552	0.178	4.026	0.148	4.198	0.604	4.592	0.41	3.482	0.162	3.298	0.29
Ti wt%	0.1	0.014	0.072	0.016	0.064	0.01	0.078	0.036	0.066	0.034	0.104	0.022	0.074	0.01	0.074	0.022
Cr wt%	0.114	0.022	0.066	0.018	0.08	0.014	0.04	0.038	0.026	0.054	0.072	0.044	0.07	0.014	0.066	0.01
Mn wt%	0.422	0.088	0.396	0.222	0.208	0.016	0.792	0.172	0.366	0.09	0.486	0.174	0.228	0.016	0.3	0.034
Fe wt%	0.636	0.108	0.416	0.106	0.348	0.058	0.552	0.078	0.536	0.454	0.59	0.074	0.422	0.036	0.414	0.042
Cu wt%	-	-	-	-	-	-	0.012	0.046	0.014	0.042	0.012	0.056	0.002	0.038	0.328	0.08

	6 outer glass	+/-	7 inner glass	+/-	7 outer glass	+/-	6 inner glass	+/-	6 outer glass	+/-	A	+/-	B	+/-
O wt%	47.427	6.476	55.308	1.794	55.544	0.516	46.754	0.612	46.984	0.386	47.15	0.458	52.162	0.526
Na wt%	9.97	1.422	3.322	1.068	2.788	0.778	8.5	0.518	8.666	0.908	3.914	0.27	4.954	0.314
Mg wt%	2.675	0.256	2.506	0.388	2.496	0.048	3.094	0.5	3.112	0.026	2.128	0.058	2.594	0.056
Al wt%	0.803	0.1	0.97	0.134	0.808	0.072	0.748	0.12	0.828	0.026	0.798	0.04	0.788	0.026
Si wt%	28.02	2.146	30.14	1.154	30.82	0.84	30.58	0.736	29.85	0.642	33.12	0.366	30.03	0.66
S wt%	0.215	0.048	0.214	0.018	0.194	0.026	0.252	0.026	0.238	0.026	0.268	0.026	0.33	0.02
Cl wt%	0.438	0.126	0.632	0.094	0.676	0.066	0.476	0.11	0.488	0.022	0.694	0.018	0.564	0.036
K wt%	2.282	0.276	1.948	0.216	2.166	0.118	2.722	0.126	2.514	0.118	2.81	0.084	2.056	0.058
Ca wt%	4.443	1.606	3.822	0.804	3.602	0.13	4.698	0.338	4.836	0.138	5.712	0.13	4.18	0.146
Ti wt%	0.103	0.138	0.072	0.016	0.074	0.022	0.102	0.008	0.104	0.01	0.104	0.022	0.076	0.01
Cr wt%	0.083	0.076	0.038	0.008	0.042	0.036	0.074	0.022	0.074	0.022	0.096	0.026	0.096	0.01
Mn wt%	0.27	0.13	0.472	0.338	0.322	0.116	0.462	0.228	0.532	0.03	0.818	0.038	0.566	0.03
Fe wt%	0.627	0.582	0.566	0.07	0.458	0.07	0.484	0.054	0.496	0.018	0.642	0.058	0.458	0.026
Cu wt%	2.64	2.708	0.012	0.026	0.016	0.05	0.016	0.01	-	-	0.026	0.042	0.016	0.034

Tab. 4. SEM chemical analysis of glass composition.

ble that the same pieces of lead was used for making the coating on the inside. Sample B, E (Ribe) and 8 (Haithabu) have also very similar isotopic compositions, and the lead used in their production might have originated from the same ore deposit. Sample B is amber coloured blown mirrored glass bead, sample E is the green hexagonal glass bead with a high lead content and sample 8 is a silver coloured blown, mirrored glass bead.

Both the lead isotope compositions signature and chemical compositions of the beads point to a limited area of raw material origin in the Near East. Unfortunately no workshops manufacturing segmented metal-foiled or blown, mirrored glass beads have been found, but our studies clearly indicate that these beads must have been made in early Islamic glass workshops somewhere in the Middle East.

The term gold-foiled beads is misleading in relation to early Viking Age segmented metal-foiled glass beads. All analyses and tests show that there are never traces of gold foil, only silver foil in these types of beads – if and when there are traces of metal foils between the two layers of glass. We have therefore chosen to employ the term 'segmented metal-foiled glass beads' in relation to these types of beads, in order to avoid confusing them with earlier types of gold and silver foil beads. It is analytically proven, that both the hollow blown glass beads and the segmented metal-foiled glass beads are manufactured using a type of glass, which was common in the Near-Eastern area. The find of the glass work-shops in Alexandria, show that the techniques involved in producing segmented glass beads were known here.

The chemical SEM analyses of the glass unanimously show a limited variation with a high level of aluminium (1.34–2.16 % recalculated to Al_2O_3), as well as a high potassium content (2.68–3.69 % recalculated to K_2O) characteristic of early Near-Eastern glass (Freestone 1991). Most of the variation can be ascribed to stochastic additions, colouring agents and the total sum effect. Analyses of the metal inside the hollow, blown glass bead shows an alloy of approximately 94 % lead with antimony (Tab. 3). The thickness of the silver foil used in making the-foiled segmented glass beads was measured to between 4 and 8 µ. The analyses of the metal show rather pure silver used for the foil. Bead 3 show a high (33.9 wt %) content of antimony which remains enigmatic but probably can be ascribed to admixture of the silvery white metal (Table 3). The result of the analyses of both the glass and silver foil in the metal-foiled segmented glass beads correlate with similar studies carried out on segmented metal-foiled glass beads from Kaupang in Norway, Birka in Sweden, Haithabu in Germany and Zawada Lanckoronska in Poland (Astrup/Andersen 1988; Zoll-Adamikowa et al. 1999).

The scientific analyses have clearly brought new light to our interpretation on the origins of the segmented metal-foiled glass beads, the hollow blown beads as well as of the high lead green hexagonal glass bead. Our studies clearly indicate that the beads have been manufactured in early Islamic glass workshops from where they have been traded to Scandinavia. Our study of imported Islamic glass beads to the market-place in Ribe have therefore been an important element in our attempts at mapping Viking Age trade routes.

Abstract
Several thousand glass beads dating to the 8th and 9th centuries have been excavated from the market-place in Ribe over the years. An essential group among these glass beads are imported beads, especially prevalent in the late 8th and beginning of the 9th century. This article presents a discussion of the segmented metal-foiled glass beads, blown mirrored glass beads and facetted drawn high lead glass beads. Lead isotope and chemical analyses of a group of these beads indicate that they were manufactured in the Near East.

Zusammenfassung
Mehrere tausend Glasperlen, die in das 8. und 9. Jh. datieren, wurden im Verlauf der Jahre auf dem Marktplatz von Ribe ausgegraben. Eine wichtige Gruppe unter diesen Glasperlen wurde importiert, insbesondere vor allem im späten 8. und beginnenden 9. Jh. Dieser Beitrag diskutiert die sog. segmentierten, mit Metallfolie versehenen Glasperlen, die geblasenen, spiegelnden Glasperlen sowie die facettierten hochgezogenen, bleihaltigen Glasperlen. Bleiisotopen- und chemische Analysen eines Teils dieser Perlen zeigen, dass sie wohl im Nahen Osten hergestellt wurden.

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