The Glass from Borg, an Early Medieval Chieftain's Farm in Northern Norway

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EXCAVATIONS at the farm of Borg on Vestvågøy Island, N. Norway, yielded an imported assemblage of glass. A programme of chemical analyses has augmented typological study, and led to new insights into the manufacture and exchange of glass in early medieval N.W. Europe.

The island of Vestvågøy in the Lofoton Isles (Fig. 1) is extremely rich in extant remains from the first millennium A.D.[1] They include about 1,000 known graves, several deserted farms with preserved remains of house sites, fences and fields, two so-called ring-formed courtyards which are thought to be connected with the functions of a chieftain,[2] and a number of boat-house sites large enough to accommodate sea-going ships. While the deserted farms are usually found in agriculturally marginal areas, the ring-formed courtyards and some of the largest boat-houses are connected with central farms which later preserved their status by having the first medieval churches erected on them.[3]

The Vestvågøy Island has two such centres, located on the western and eastern half of the island respectively, the eastern one formed by the two neighbouring farms of Borg and Bøstad. It had been identified, even before the excavations took place in the 1980s, from the presence of a well-preserved grave field, three large boat-house sites (two of them over 20 m long), a small ring-formed courtyard and several deserted farms on the outskirts of the two main farms; it was also the site of the medieval church.[4] Trial excavations[5] in the ring-formed courtyard gave a date of A.D. 130–260,[6] while the largest boat-house site, which is 26 m long, was dated to the late Viking Age, A.D. 890–1030.[7] If we accept both as indicators of a central or chieftain's farm, Borg-Bøstad thus seems to have enjoyed this status for almost the entire first millennium A.D.

The site itself was discovered in 1981 when the local farmer started ploughing the land and revealed not only settlement traces but unexpected finds such as tin foiled pottery and gold foiled glass,[8] indicating that the site had potentials far beyond an ordinary settlement site.[9] The excavations took place between 1983 and 1989; the

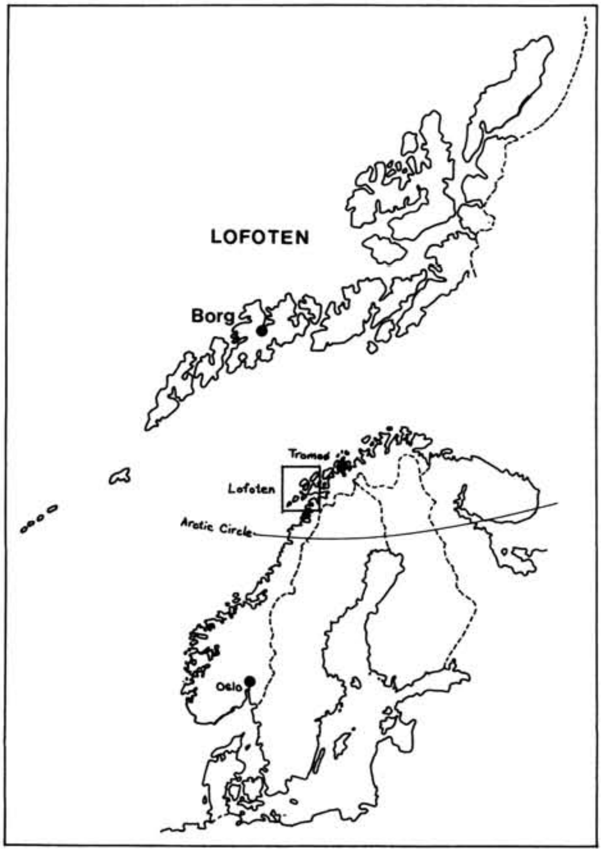

FIG. 1
Location map for Borg. (Drawing by I. Holand)

first two years as small-scale rescue excavations, but from 1986 organized as a joint Scandinavian research project, involving participants from Norway, Sweden, Denmark, Finland and England.[10]

The site, which lies at the W. end of an exposed hill where the medieval church was once located, and where the modern church today occupies the highest point,[11] covers an area of approx. 2000 sq.m and contains a number of different structures from the period A.D. 200–1000, as indicated by radiocarbon dates and finds. The excavation has, however, concentrated on two houses. The main building (House I) is a three-aisled longhouse, rebuilt and extended several times over more than 500 years. The latest phase, from the Merovingian and Viking Periods (A.D. 550/600–1000), is the largest such house ever excavated in Scandinavia: 83 × 9 m, with an area of nearly 750 sq.m (Fig. 2). Its size and location must have made it a dominating focal point in the community, just as the church is today. About half was probably used for stables and storage (rooms D–E), while the other half was divided into two living rooms (A and C) with an entrance hall (B) in between. Radiocarbon dates from the house range mainly from the migration period to the late Viking Age (Fig. 3).

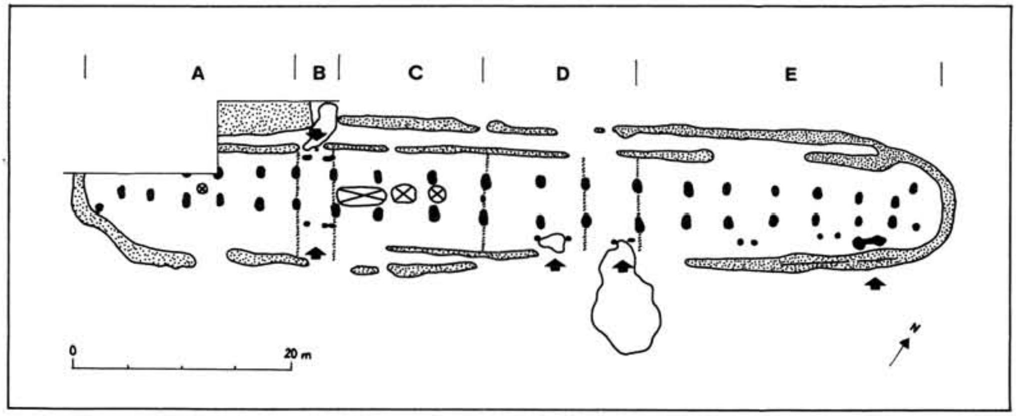

FIG. 2

Plan of House I, latest phase. (Drawing by I. Holand, based on a sketch by D. Kaldal Mikkelsen and F. Herschend 1989, published in Stamsø Munch 1991; see note 9)

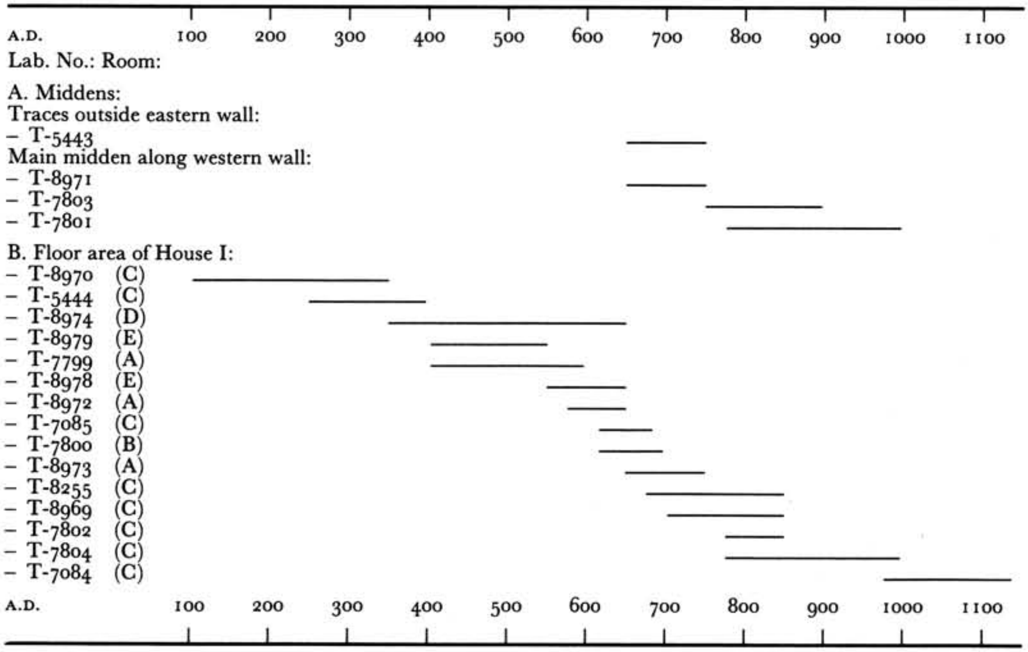

FIG. 3

Radiocarbon dates from House I; see also Appendix 1. T-8970 unexplained, and T-5444 stratigraphically older than House I. (Based on preliminary compilation by O. S. Johansen for the Borg Symposium in Tromsø (1990))

In addition, a smaller house (House II) was excavated next to the main building, and trial trenches dug in other structures some distance away from the main area.[12] House II appears to be contemporary with the youngest phase of House I, but was surprisingly empty of finds. This is not the case with House I, which has yielded nearly 3,500 of the 4,500 finds recorded from the excavation; 1,300 of these are connected with living room C.[13] Because of the quality of some of these finds and a row of hearths along the central aisle, the room has been interpreted as a guild hall.[14] Finds of loomweights and spindle whorls, however, indicate that it was also the everyday living and work room for the women in the family.[15]

THE FINDS[16]

The many reconstructions of House I and modern agricultural activity have mostly destroyed datable stratigraphical contexts and the vertical distribution of finds. Dating of finds is thus based mainly on the objects themselves. The horizontal distribution of finds attributed to the oldest and youngest phases of House I still, however, corresponds surprisingly well with the different lay-out of the house in the two phases. This suggests that displacement due to modern ploughing is fairly structured, and that the horizontal distribution still reflects original disposition.[17]

The vast majority of finds are of types and materials which undoubtedly represent local production. Most numerous are finds of iron, iron slag, steatite and clay, making up nearly 80% of the total number of finds. This is partly due to the fragmentation of some of these materials. Other materials, such as flint, pumice and slate, make up another 10%, and a wide variety of local materials about 5%. Only about 2% of the finds can be safely dated to the oldest phase of the settlement, i.e. the migration period, namely local pottery and objects of quartzite.

IMPORTED FINDS

Imported finds include bronze jewellery and other bronze objects, among them fragments of a hanging bowl, and some tiny gold objects: five gold foil pictures of a man and a woman embracing, a small filigree ornament of unknown function,[18] a flat(tened) gold bead and a small circular gold mount. There are also a few tiny silver objects,[19] some jewellery pieces in amber and jet, a number of glass beads, but above all, fragments of wheel-thrown pottery and glass vessels. The pottery fragments represent two tin foiled jugs (Tating ware) and a few, as yet, unidentified sherds of light brown pottery.[20]

Imported finds constitute only 6% of the total number, and are almost entirely connected with House I and, it seems, its youngest phase(s). Of 263 imported finds, only fifteen were found some distance away from the house, many of them having been transported there by modern agricultural activity. Within the house nearly 80% of the imports came from the assumed 'guild hall' (room C) and, even more specifically, its N. corner, with most of the remainder coming from living room A.

INITIAL ANALYSIS OF THE GLASS VESSELS: PROBLEMS, METHODS AND CONSIDERATIONS

Initially 115 glass sherds were classified as 1st millennium A.D. glass and another three sherds as possibly from that period. The visual classification indicated that ten to twelve vessels were represented, among them a blue bowl with yellow reticella cables, a light blue-green claw beaker, a nearly colourless vessel decorated with gold foil, a couple of ribbed vessels, and several light green, undecorated vessels.[21]

The similarity of the imports to those from Kaupang in S. Norway or Helgö in Sweden was obvious at an early stage, but a brief examination of the glass finds from Kaupang, Helgö and Ribe in 1985/86[22] also showed crucial differences. Not only was the quantity of glass found at these sites much bigger, the most striking feature was the heterogeneity of the southern material. This has led to suggestions that the glass was imported, not only as whole vessels, but also as glass cullet intended for other purposes, such as bead production. Alternatively the assemblages may represent the remains of broken glass vessels collected on the sites for the same purpose. Such a production certainly took place at Ribe, where all stages of bead production are well documented[23] and is probably the most likely explanation for the presence of glass rods both at Helgö[24] and Kaupang.[25]

At Borg, however, nothing but vessel fragments and complete beads were found. Moreover, the fragments were identified as belonging to a limited number of vessels, thus indicating that the import had been in the form of complete vessels. It was, however, difficult to establish the exact vessel number visually, whether certain sherds belonged to particular vessels and whether the three uncertain sherds should be regarded as early medieval or modern glass. To help resolve these problems, it was decided to carry out chemical analysis on a range of glass samples. Thirty-three sherds were chosen, based on the initial classification and the problems encountered. Apart from establishing the chemical composition of the glass, the analysis would attempt to answer specific questions about the number and types of vessels by testing the visual classification of sherds as belonging to specific vessels against their chemical compositions. Also, by comparing the compositions with an established technological framework for glass production, it was hoped that a date could be *suggested*. This was particularly important for the uncertain sherds, which were all unusual single sherds. Included in the analysis were also three sherds considered to be modern (Table 1, analyses 35–37, sherds Q, T and U).

GLASS ANALYSES

ANALYTICAL TECHNIQUE AND SAMPLING

The analytical technique used was electron probe microanalysis. The system was a Cambridge microscan 9 electron microprobe, with wavelength dispersive spectrometers. Typically each sample was analysed using a defocused electron beam of 80 microns; at least three analyses were carried out on each sample and the results for 22 element oxides are given in Table 1. The samples used were of *c.* 1 mm across and were mounted in epoxy resin blocks prior to polishing and coating with a thin

TABLE I

THE CHEMICAL COMPOSITION OF THE GLASS ANALYSED FROM BORG (weight per cent element oxide)

Vessel (Table 2)	A	A	A	A	A	A	A	B	B	C	C	C	C	D_1	D_2	D_2	D_2	D_3	D_4
Sherd No. Ts-8336	a+g	a+g	h	c	c	d	d	ji	ji	dn	fm	ez	dk	ét+eu	fa	em	dw	ex	jl
Colour	cobl	col	cobl	cobl	dgr	cobl	'blk'	pgr	pgr	col	pgr	pgr	pgr	olgr	pgr	pgr	pgr	pgr	pgr
Matrix/ Decn.	M	cable	M	M	cable	M	cable	M	cable	M	M	M	M	M	M	M	M	M	M
Analysis number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Na_2O	15.4	15.2	17.0	16.3	7.7	17.6	13.0	15.0	15.5	16.9	17.6	17.6	15.6	15.9	14.6	14.3	16.9	15.8	16.9
MgO	0.7	1.0	0.7	0.7	0.4	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.7	0.9	0.9	0.9	0.9	0.9	0.7
Al_2O_3	2.5	2.7	2.2	2.2	1.9	2.3	3.3	2.7	2.8	2.6	2.3	2.1	2.2	2.8	2.7	2.6	2.6	2.7	2.2
SiO_2	70.2	67.5	67.7	67.0	41.0	69.2	68.9	71.3	69.9	67.9	68.0	69.3	70.1	67.3	71.6	68.2	66.5	67.6	68.4
P_2O_5	0.1	0.2	0.1	ND	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	ND	0.2	0.1
SO_3	0.3	0.1	0.2	0.2	0.3	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.3
Cl	0.7	0.7	0.5	0.8	0.7	0.7	1.0	0.9	0.9	1.1	0.8	0.8	0.8	0.8	1.0	0.9	0.5	1.0	1.2
K_2O	0.7	1.0	0.6	0.6	0.5	0.6	0.5	0.5	0.6	0.9	0.8	0.9	0.9	0.9	0.6	0.8	0.9	0.9	0.7
CaO	6.5	7.2	6.7	6.4	4.2	7.3	8.9	7.6	7.4	7.3	6.6	6.4	6.4	6.9	6.9	7.0	6.8	6.8	6.3
TiO_2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	ND
Cr_2O_3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MnO	0.5	0.6	0.6	0.5	0.4	0.5	ND	ND	ND	0.8	0.8	0.7	0.7	0.5	0.6	0.6	0.6	0.5	0.8
Fe_2O_3	1.1	1.0	1.0	1.0	1.5	1.1	0.6	0.6	0.5	0.8	0.7	0.7	0.6	1.0	0.9	1.0	0.9	1.0	0.7
CoO	0.1	ND	0.1	0.1	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NiO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CuO	0.2	0.3	0.2	0.2	0.1	0.2	2.9	1.5	1.4	ND	ND	ND	ND	0.6	0.6	0.5	0.5	0.7	0.7
ZnO	ND	ND	ND	ND	ND	ND	0.1	0.1	0.2	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND
As_2O_3	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SnO_2	ND	0.1	ND	ND	4.3	ND	0.1	0.1	0.1	ND	ND	ND	ND	0.1	0.2	0.2	0.1	0.1	0.1
Sb_2O_3	1.6	0.3	3.4	2.5	ND	2.5	ND	ND	1.3	0.3	0.3	0.3	0.3	0.7	0.6	0.8	0.4	0.8	1.7
BaO	0.1	0.1	ND	ND	ND	ND	0.1	0.1	0.1	0.1	0.1	0.1	ND	ND	ND	0.1	ND	ND	0.1
PbO	0.3	0.6	0.2	0.3	34.9	0.5	1.5	0.2	0.2	0.1	0.1	0.1	0.1	0.8	1.0	1.1	1.0	1.1	0.9

Vessel (Table 2)	D_5	D_6	E	F	H_1	H_2	I	I	J	G_1	G_1	G_2	G_2	G_2	G_2	Q	T	U
Sherd No. Ts-8336	fs	dl	dc	eå	dh	ev	jn	jn	aæ	ew+ey	dy	fo	en	fn	eø	mod æs	mod æl	mod æb
Colour	pgr	pgr	pgr	near	pgr	pgr	olgr	olgr	yegr	olgr	pgr	pgr	pgr	pgr	pgr	pgr	olgr	olgr
Matrix/ Decn.	M	M	M	col M	M	M	M	cable	M	M	M	M	M	M	M	M	M	M
Analysis number	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Na_2O	16.0	14.6	15.9	17.4	16.1	16.8	15.5	17.7	18.7	3.7	3.7	1.1	1.1	1.0	1.0	5.5	5.9	0.5
MgO	0.9	0.9	0.8	0.7	0.9	0.9	1.2	1.0	1.2	7.0	7.0	5.5	5.2	5.1	5.1	3.6	4.0	3.4
Al_2O_3	2.6	2.8	2.6	2.4	2.7	2.4	2.9	2.6	2.8	4.6	4.5	3.1	2.9	2.9	2.9	8.4	5.0	3.2
SiO_2	65.5	67.8	69.1	69.6	66.8	67.7	71.2	67.5	66.7	55.3	53.4	61.6	60.7	58.9	56.1	54.0	58.4	55.5
P_2O_5	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	ND	3.5	3.3	2.1	2.0	2.3	2.0	1.5	0.5	0.6
SO_3	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	ND	0.1	ND	0.1	0.1	0.1	0.2
Cl	1.1	1.1	1.0	1.3	0.6	0.6	1.3	1.2	0.9	0.3	0.3	0.5	0.5	0.4	0.4	0.8	0.4	ND
K_2O	0.8	0.8	0.9	0.6	0.9	0.9	0.4	0.4	0.4	10.6	10.5	13.1	13.4	13.2	13.0	3.0	3.4	6.9
CaO	6.8	6.9	7.0	6.0	6.9	6.8	5.6	6.0	5.3	12.7	12.5	11.6	11.2	11.5	11.4	19.5	18.9	21.0
TiO_2	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.4	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.1
Cr_2O_3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MnO	0.6	0.6	0.7	0.6	0.6	0.7	2.5	2.2	2.4	0.8	0.7	0.6	0.7	0.6	0.6	0.9	0.9	1.1
Fe_2O_3	0.9	1.0	1.0	0.6	1.0	1.1	1.7	1.5	1.7	1.7	1.7	1.4	1.2	1.4	1.4	2.9	1.7	1.3
CoO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NiO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND
CuO	0.5	0.5	0.2	ND	0.4	0.6	ND	ND	ND	ND	ND	ND	0.6	ND	ND	ND	ND	ND
ZnO	ND	ND	ND	ND	ND	0.1	ND	ND	ND	0.1	ND	0.1	ND	ND	ND	0.1	0.1	ND
As_2O_3	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	0.1	ND	ND	ND
SnO_2	0.2	0.2	0.1	ND	0.3	0.2	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND
Sb_2O_3	0.5	0.5	0.3	0.5	0.5	0.6	ND	ND	ND	ND	ND	ND	0.7	ND	ND	ND	ND	ND
BaO	0.1	0.1	0.1	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND
PbO	1.1	1.2	0.7	0.1	1.7	1.6	ND	ND	ND	0.2	0.2	ND	0.8	ND	ND	ND	ND	0.1

Notes: ND = Not Detected; cobl = translucent cobalt blue; col = transparent colourless; near col = translucent very pale green (nearly colourless); dgr = translucent dark green; pgr = translucent pale green; olgr = translucent olive green; yegr = translucent yellow green; 'blk' = very dark translucent; mod = modern.

Typical levels of detection in p.p.m. (95.5% probability level) are:

Na_2O	760
K_2O	250
CaO	170
Fe_2O_3	640
CuO	1200
PbO	200

carbon layer which prevented distortion and deflection of the electron beam. A full description of the analytical technique used is given elsewhere.[26]

FIRST MILLENNIUM GLASS TECHNOLOGY

In order to ascertain the possible technological influences and/or sources of Borg glass, it is necessary to provide a brief description of how 1st millennium glass technology developed. Roman period glass is a soda-lime-silica type and was made using silica (a source such as sand or quartz) a lime-rich raw material (occurring as impurities in sand, for example) and soda (probably introduced as a mineral). In addition, this soda-lime glass is characterized by low levels of potassium and magnesium oxides; it is known as low magnesia glass (LMG).[27]

In the 1st century A.D. fine cast and polished glassware with features in common with late Hellenistic technology are found;[28] these are often deliberately coloured or colourless. The colourless glass, in particular, is of very high quality and has been found at sites such as Fishbourne.[29] Recent chemical analysis has helped to define the level of specialization involved in its manufacture.[30] In addition, Brill's[31] detailed analytical survey of Roman diatreta (the Corinth cup, the Athens cup and the Benaki cup) revealed the high technological standard achieved. Although LMG continued to be used through to the 4th century, vessels and bangles incorporating specialized opaque glasses for polychrome decoration were also in use. Analyses carried out on the 1st- to 3rd-century glass from Silchester,[32] 1st- to 4th-century Roman glass from York[33] and the 4th-century glass from Jalame, Palestine[34] show the persistence of the soda-lime-silica technology.

Analyses on 5th-/6th-century glass from Cadbury Congresbury[35] show that there was continuity in the established pattern of LMG technology into the early medieval period. Some of the decorative millefiori glass used in the Sutton Hoo hanging bowl escutcheon was manufactured in the Roman *tradition*.[36] It is, however, an open question whether separate glass batches were melted for vessel production in Anglo-Saxon England, or whether only Roman glass was being recycled at the time. It is more likely that glasses of individual decorative opaque colours such as those used as one component in cables — as in the Borg cable-decorated vessel — were melted independently for the manufacture of vessel decoration, beads and bead decoration. Recent evidence from Early Christian Ireland (6th–8th century) has provided evidence for the production of such specialized opaque yellow glass in the 'Celtic' tradition from primary raw materials there.[37] A further potential component or admixture in Borg glass is opaque white and red Roman tesserae.[38] These Roman enamel and tesserae colours have the same major, minor and trace components as found in some early medieval glass with similar colours, showing that the same production technologies were involved or, more plausibly, that Roman tesserae were recycled.

Impurities of antimony, tin and lead oxide frequently found in early medieval glass (such as some from Borg) were not detected in glass from Roman Jalame[39] and Silchester.[40] In Scandinavia, analysis of glass from Ribe, Jutland, and Åhus, Scania, has also shown that it was manufactured in the basic soda-lime-silica tradition and that much of the translucent glass has the same antimony, tin and lead oxide impurities found in other early medieval glass. These impurity patterns also run through some of the translucent glass used in millefiori and cable ('reticella') glasses. The existence of such compositional links underlines the importance of investigating a range of glass products (vessels, windows, beads, millefiori, cables, enamels and tesserae) because it can shed light on the relationship between various aspects of contemporary glass technologies where raw materials might have been shared. As mentioned above, compositional links can be made between Roman opaque tesserae and enamels and opaque glasses used for early medieval cable and millefiori glasses; this appears to indicate that a degree of recycling took place.

During the 9th century, the first signs of a major change in western glass technology occurred. At this time the balance of alkalies (sodium and potassium oxides) starts to change from a high soda glass to a mixed alkali and eventually a potassium glass. The transition has only been detected in a small proportion of vessel, window and bead glasses analysed, but nevertheless indicates that the technology, which had been very conservative in its use of major raw materials, had started to change in a radical way. The use of mixed-alkali glass might indicate that the demand for soda far outstripped the supply and a potassium-rich raw material was exploited, or it could indicate that the soda supply was becoming restricted, perhaps for political reasons (e.g. disruption from the Islamic world).

A potential source for Borg glass is that produced by Byzantine technology. An analytical study of Byzantine glass tesserae by Freestone *et al.*[41] has shown that three groups of tesserae from 5th-century Shikmona (Israel), 10th-century Hosios Loukos (N. Greece) and 11th- to 13th-century San Marco, Venice (Italy) have chemical compositions which reflect their period and geographical origin, with the 'typical' Roman LMG being used for the Shikmona glass, Islamic high magnesia glass (HMG) for the Greek glass and a mixed-alkali composition for the Italian glass. The composition of Islamic vessel glass is generally of LMG until A.D. 845 and after this date HMG is used.[42]

The glass technologies discussed above provide a broad framework within which to compare the Borg glass and provide some potential sources for the Borg glass.

THE TECHNOLOGY OF BORG GLASS

Most of the Borg glass falls into a broad soda-lime compositional bracket, with low magnesia (LMG), and it lacks the diagnostic compositional characteristics of post 9th-century Islamic glass (see Table 1). However the range of glass vessel forms and glass colours analysed contained interesting impurity patterns and provided further insights into early medieval glass technology. The translucent glass (apart from vessels G1–2 and the modern fragments: Table 1, analyses 29–34 and 35–37) contains soda at between 13% and 17.7%, calcium oxide at between 5.3% and 8.9% and silica at between 65.5% and 71.6%, showing a relatively low variation in major components. Of the minor components, alumina (Al_2O_3), which is thought to have been introduced as an impurity of sand, and/or by migrating from the crucible wall into the melt, is found at between 2.1% and 2.9% and manganese oxide (MnO) occurs at between 0.4% and 0.8%. Apart from phosphorus, sulphur, titanium and iron oxides, and chlorine, which were probably introduced as impurities in the alkalies or in the sand, many of the remaining components were probably introduced as colourants, or associated with colourants, in the glass batch.

The first unexpected result from this analytical survey is the presence of six glass samples of an entirely different composition (Table 1, analyses 29–34). These glasses are potassium-rich, with levels of between 10.5% and 13.4% potassium oxide (K_2O). Each of the six vessel fragments also contains significantly higher magnesium, phosphorus and calcium oxides than found in the Borg soda-lime glasses. All these are compositional characteristics of European high medieval glass, though the calcium oxide levels are normally significantly higher in high medieval glass (up to 20%) than the levels found in Borg glass (11.2–12.7%). The composition of the two vessels G clearly shows that two separate technologies were used for the manufacture of the Borg glass; although a high potassium glass, the balance of other oxides in vessels G makes it surprisingly durable. The compositional differences can probably be attributed to different alkali sources; type G glass may have been manufactured using a plant ash, whereas the remaining soda-lime glasses were probably originally made using a mineral alkali. This is not the first time that glass of a transitional character of an early date has been found. Glass from Lurk Lane, Beverley,[43] of 9th-/11th-century date, from Peel Castle, Isle of Man, of early 10th-century date,[44] from France, of 8th-/9th-century date,[45] from Cordel[46] and a single arcade-decorated beaker fragment from Ribe[47] all exhibit compositional characteristics of this kind.

Some of the glass objects from Hedeby were analysed by Dekówna;[48] these were mainly glass beads, though amongst the samples are some high potassium glass fragments and linen smoothers.[49] Unfortunately the excavations do not permit the dating of these objects before the 11th century with any confidence; however, there are badly weathered (presumably high potassium) linen smoothers from sites such as Dorestad thought to be older than the 9th century.[50] Although there is a level of similarity between the Borg high potassium glasses and those published by Dekówna, there are nevertheless differences: lower magnesia and alumina levels in all the Hedeby glasses (it is unlikely that these differences can be attributed to the use of different analytical systems) and higher calcium oxide levels in four of the Hedeby glasses. These are close to the chemical compositions of European high medieval cathedral window glass.

At Beverley the potassium-rich glass is window glass, at Peel it is found in beads, and in France in a glass vessel. Other chemical analyses of beads and linen smoothers by Dekówna[51] provide further evidence for a general transition in compositions; the glass in a crucible from Szczecin, Poland, of 9th- or 10th-century date is of great interest, though it is uncertain whether the glass was being fused there from primary raw materials. The fragments from Borg with a transitional composition are therefore extremely important in helping to monitor the introduction of, and experimentation with, new raw materials in early medieval glass production. The context dating for these six vessel fragments with a transitional composition is *c.* A.D. 550/600–1000.

The probable 9th-/10th-century glass production site at Cordel[52] yielded glass-bearing crucibles.[53] The glass compositions published[54] have a high calcium oxide (23% and 23.3%), high magnesium oxide (3.7% and 7.0%), mixed alkali (sodium oxide 8.4% and 8.1%; potassium oxide 8.2% and 11.5% respectively) composition. Although these characteristics are close to the composition of high medieval glass in W. Europe the mixed-alkalies distinguish it from more typical high potassium oxide glasses. More recent analyses of the material[55] show that the silica glass adhering to the inner faces of crucibles contains predominantly potassium oxide with high levels of magnesia. There are similarities between the published (mixed-alkali) Cordel compositions and the unusual potassium-rich glasses from Borg. Though the Borg glasses contain significantly lower soda and calcium oxide levels than in the published compositions they compare quite closely to the unpublished Cordel compositions. The date of the glass industry at Cordel has been called into question[56] though the interim analyses infer a 9th- to 10th-century date; further analytical investigations may provide more substantive evidence for this transitional glass technology.

The rest of the glass compositions from Borg proved to exhibit different compositional characteristics, many of the low magnesia soda-lime-silica glass type. Nevertheless, by a close consideration of the lead, antimony and tin oxide levels it was found that four other compositional 'groupings' were discernable (Fig. 4a–b). The scattergram presented here is plotted using the figures corrected to two decimal places so as to separate the points; in Table 1 the compositions are quoted to one decimal place. One of the groupings of vessel compositions in Fig. 4 is made up from the gold foil decorated beaker fragments and contains low levels of all three 'impurities', though antimony trioxide may contribute to nearly decolorizing one of the fragments. These low impurity levels suggest that the gold foil vessel glass was made using purer raw materials than found in the other glass analysed and strengthens the impression that raw materials were carefully selected and that the highly skilled use of gold foil was not the only aspect of specialization in their production. The materials were nevertheless iron-rich, and in all four samples the manganese to iron ratio is very similar; three samples were of a pale green colour, the fourth nearly colourless and there is a possibility of fragments from two vessels being present.

There is a significant compositional difference between the colourless glass used for cable decoration in the filigree-decorated Borg vessel (Table 1, analysis 2) and that used for the nearly colourless and pale green gold vessel fragments (Table 1, analyses 10–13): the cable glass had comparable levels of impurities to those found in most palm cups/funnel beakers from Borg indicating that a different (less refined) source of primary or secondary raw materials was used for its manufacture than in the gold glass; the production centre for the glass used in the gold glass vessels may have been the Rhineland and that for the cables possibly further west. There is evidence for the production of cables in the west at sites such as Barking Abbey, Essex, but as yet the evidence for fusing the glass used, from primary raw materials, is lacking. There is a significant difference, particularly in the decolourant (antimony trioxide) level used, in Roman and early medieval colourless glass; the levels of

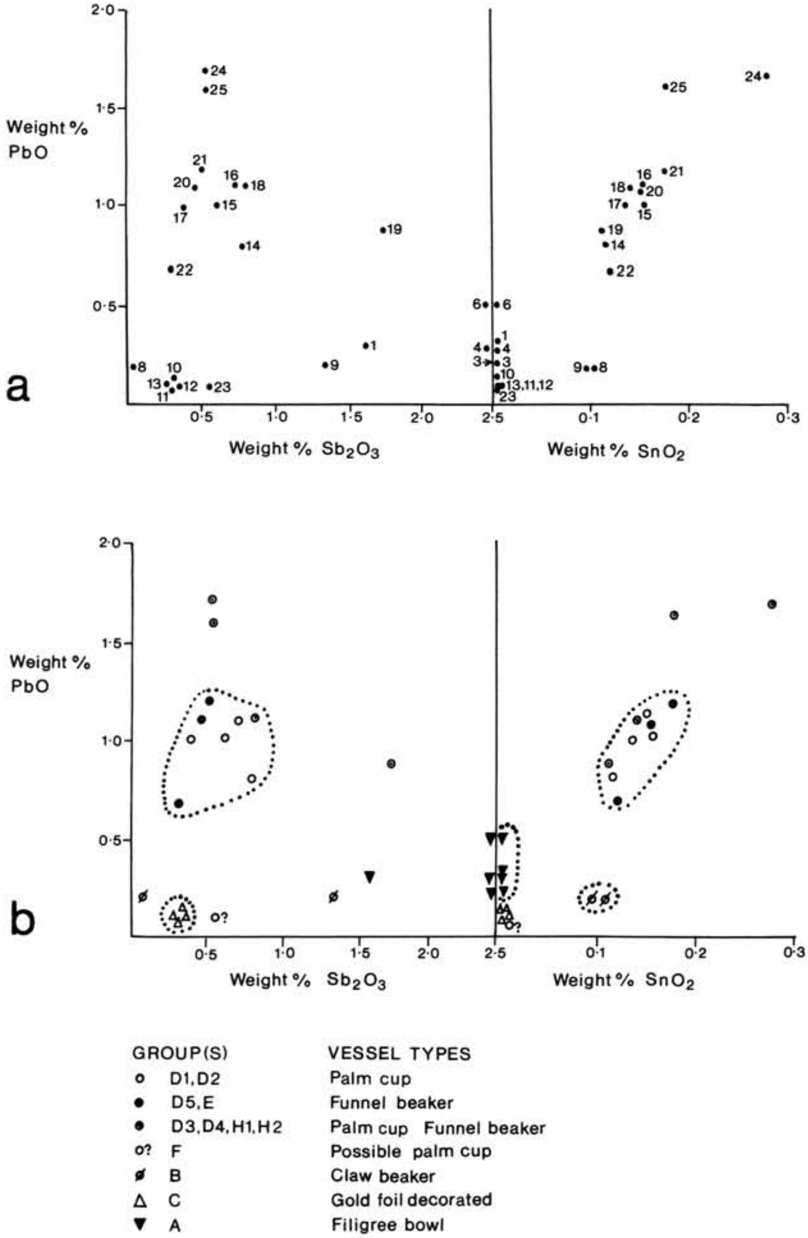

FIG. 4

(a) Weight percent lead oxide (PbO) vs. weight percent antimony trioxide (Sb_2O_3) and vs. weight percent tin oxide (SnO_2) in soda-lime-silica glass vessel fragments from Borg, Norway. (N.B. The potassium-rich glass (Group G), modern glass and analyses 26–28 (Groups I and J) are compositionally distinct in other ways and not included here.) (b) The allocation of vessel types for data plotted in (a) and their relationship to vessel groups antimony and manganese oxide in early Roman vessels are generally much higher, so the gold glass production can be regarded as a more tightly controlled technology.

The refined 3rd- to 4th-century colourless glass used for the manufacture of gold glass from the Catacombs in Rome[57] is, in some cases, a similar composition to the Borg gold foil vessel glass, with comparable antimony and manganese oxide levels, though not always accompanied by the lead oxide impurities found in the Borg vessels (there is variation in the chemical composition of the Catacombs glass). Some Catacombs glass contains only antimony trioxide as a clarifier and decolorizer, and other fragments, as found in the Borg glass, contain both antimony and manganese oxides. Some of the Catacombs glass could have formed the basis for the Borg gold glass, the greenish tinge being incorporated by the variation in oxidizing-reducing conditions during heat treatment of the glass.

The group which is mainly composed of funnel beaker/palm cup fragments (Fig. 4) is characterized by a high lead oxide impurity level of *c.* 1% and variable, but significant, antimony trioxide levels. A considerably larger data base is necessary before the full significance of these impurity levels can be assessed. The cobalt blue filigree bowl(s) contain high antimony trioxide levels which *may* be due to the use of an antimony-rich cobalt source as a colourant, though this seems unlikely. A more likely explanation is that the antimony could have been present in a colourless base glass used, providing a close control over the blue colourization produced. Either way, it has led to a chemical characterization for the glass.

The two samples of an assumed claw beaker have low impurity levels of lead oxide and *c.* 0.1% tin oxide. These blue-green fragments are coloured by relatively high cupric oxide levels; the applied glass has very similar chemical characteristics as the body of the vessel so the same melt may have been used to produce both. Although only two samples are involved, they appear to be significantly distinct from the palm cup/funnel beaker series. Analyses 24 and 25 (Fig. 4a) of palm cups or funnel beakers are characterized by high lead oxide and tin oxide impurities and appear to be sufficiently different from the rest to warrant allocation to a separate 'group' from the other funnel beakers/palm cups.

Overall the analyses of Borg glass have provided an unexpected means of characterizing the glass; vessel type/form and chemical characteristics are, to some extent, correlated (Fig. 4a–b). The approach might be criticized because more samples could cause the groupings seen in Fig. 4 to merge or diverge. However, the positive correlation between per cent lead oxide and per cent tin oxide in palm cups and funnel beakers may prove to be a significant discriminatory characteristic for the vessel form or between production areas. The chemical analysis has also provided a means of grouping glass fragments into a minimum number of vessels; there is always a possibility that more than one vessel was made from the same melt, in which case the vessel numbers are certainly to be regarded as a minimum number. However, the vessel form and joins amongst the vessel fragments provide further means of creating links between vessel fragments (see below). Another unexpected finding is the use of potassium-rich glass used for making ribbed vessels.

COMPOSITION OF 'HIGH' AND 'LOW' STATUS GLASSES

It can be argued that the finest glass metal is that in which the impurity levels are negligible, since this probably reflects a lack of glass recycling and the exploitation of relatively 'pure' raw materials. The gold glass, although both colourless and green, does not contain the higher impurity levels found in many of the pale green vessel forms analysed (Table 1). Since it is suggested that antimony, tin and lead oxide levels represent uncontrolled (accidental) impurities, their lack (or undetected levels) in gold glass vessels indicates a different origin (possibly the Rhineland) and/or the existence of production of high and low standards of quality at the same location, perhaps for different levels of society. The high antimony levels in the filigree bowl(s) may have resulted from the use of a base glass which had been deliberately decolorized with antimony and to which the cobalt blue colourant was added. This again could suggest that such control of trace components was deliberate (even if 'inherited' in this case).

Two fragments of an assumed claw beaker, possibly made in England, also have relatively low impurity levels. The remaining groupings formed from palm cups/funnel beakers have high impurity levels (with a positive correlation between lead and tin oxides) which suggests that they were made in a different production centre from the claw beaker; it is also possible that the same centre used different raw materials over time. With the change in raw materials that these different impurity patterns suggests, the working properties of the glass would have been very similar, if not the same, and it is therefore unlikely to have occurred for technological reasons.

THE RELEVANCE OF GLASS ANALYSES TO THE STUDY OF EARLY MEDIEVAL GLASS AND GLASS PRODUCTION

The determination of glass chemical compositions by chemical analysis is difficult and painstaking, but can potentially provide both technological and archaeological information on a number of levels. The determination of major components (soda, calcium oxide, silica, potassium oxide and lead oxide) establishes the basic technology used. The minor components which are thought to have been introduced with these major components, such as magnesia, phosphorus pentoxide and chlorine with alkalies, and titanium and alumina probably with the sand, also help to suggest the use of a particular alkali and the nature of the silica source. On the other hand, the deliberate addition of colourants and decolourants sometimes brings other trace oxides with them, and these can help to identify the kind of colourant used and sometimes their sources. On top of all these oxides, the incidence of others in Dark Age glass, for which an origin cannot easily be suggested, such as antimony, tin and lead could provide a means of sourcing glass and glass production in early medieval Europe. Sanderson and Hunter[58] for instance, found some compositional distinction between Dorestad glass and Southampton and Helgö glass based on the levels of antimony detected, one of the element oxides found to be discriminative here, too.

The unexpected groupings found amongst the vessel fragments analysed (Fig. 4) are due to 'impurity' levels of lead, antimony and tin oxides, some at relatively high levels; normally when these oxides are present at high levels it is because they are deliberately used as colourants or opacifiers in the glasses. The groups are not large, but there is a real distinction between the filigree bowl glass, the palm cups/funnel beakers, the gold-foil decorated vessel(s) and the probable claw beaker. In addition, the chemical composition of the potassium-rich glasses, not included in Fig. 4, is completely different from the rest.

One of the reasons why these analytical variations and groupings have not been noted before is that some analysts have not determined the levels of the number of oxides analysed here (22) on a routine basis, and specifically not antimony and tin together.[59] Having illustrated that lead, antimony and tin impurity levels are important to the scientific study of early medieval glass it is necessary to explain their presence in the glasses. One possible source is through the introduction of Roman tesserae in the glass melt to increase its volume. Roman glass tesserae are almost invariably characterized by a relatively high antimony content, as calcium antimonate crystals, which render them opaque, and this is one of very few possible sources for antimony oxide in early medieval glass. This does not necessarily indicate that glass was *not* being manufactured from primary raw materials somewhere in early medieval W. and N. Europe, but it may suggest that there was a steady supply of tesserae. A possible explanation for the lead and tin oxide impurity levels in early medieval glass is that, for some reason, a leaded tin bronze alloy was introduced (copper is almost invariably found in these glasses as well). Significantly, there are two early medieval vessel types from Borg in which no copper oxide was detected. These are the gold glass fragments (which nevertheless contain antimony) and the six potassium-rich vessel fragments (analyses 29–34), plus a further single sample (23). The last analysis was originally separately classified from the others (14, 18, 20–21, 24) which all contain copper oxide at between 0.4% and 0.7%. The fact that copper oxide was not detected in the gold glass creates another putative compositional link with the late Roman colourless gold glasses from the Roman Catacombs in which none was detected. The lack of copper oxide in the possible ribbed funnel beakers (G1–2) strengthens the original classification of the vessels prior to chemical analysis distinguishing between two main groups of palm cup/funnel beaker fragments. None of the 'modern' fragments analysed contained copper oxide either.

The analyses have also produced purely technological information about the colourants and opacifiers used. Cobalt oxide was identified as the principal colourant in the filigree vessel glass (analyses 1, 3, 4 and 6) and copper (cupric) oxide as being an important contributor to the sea-green colour in analyses 8 and 9. A variation in the oxidizing-reducing conditions is a likely explanation for the olive green colour of analyses 26 and 27, though the incidence of higher levels of lead oxide (antimony and tin oxides) would possibly also affect the final colour produced, even with the same gross chemical composition. The only glass analysed with a very high lead oxide content (34.9%) is analysis 5, a dark green component of an applied cable. Though described as dark green it contains a lead stannate component which would normally produce an opaque yellow colour in glass, but here it is enveloped in translucent green glass, so it appears dark green. This is an interesting effect, though not unusual in early medieval glass technology. The composition of the opaque yellow component of the cables applied to the other two filigree fragments analysed would also be expected to be lead stannate. The 'black' streaks in the opaque yellow cable applied to the third fragment are due to 2.9% copper oxide (analysis 7) and this is an unusual feature of the decoration, possibly added when the cable was formed. Lead stannate has been found in the opaque yellow part of the 'reticella' rods used for the decoration of vessels from Anglo-Saxon Southampton[60] and the composition is very similar to that detected here.

GLASS TYPOLOGY AND DISCUSSION

The results of the chemical analysis correlated well with the broad conclusions of the visual classification, but also served as an invaluable corrective in two different ways: a) the identified number of vessels increased, and b) they prompted a careful reconsideration of the dating of certain vessels, when the sherds were identified as potassium-rich glass. Using variations in trace and/or minor and major element oxides to distinguish between vessels of the same type, but made from different batches, was considered justified because several analyses on the same fragment, and analyses of several samples from the same vessel showed a very close compositional similarity. The only qualification is that different vessels made from the *same* glass melt would have indistinguishable compositions, making visually identifiable characteristics, such as thickness, colour, and size and distribution of gas bubbles more important. The following presentation of the vessels identified at Borg is therefore based on a synthesis of data from the archaeological and scientific lines of investigation. The analysis numbers quoted are for the results in Table 1, while Table 2 gives a descriptive summary of the number of sherds found, their diameter, colour and decoration for the ascribed vessel types.

The vessels, which are dated on typological and compositional grounds only, seem to cover the period A.D. 550–1000. The suggested datings indicate that three vessels (B, D1–2; see Table 2) *may* be older than A.D. 700, while six (A, C, D3, F, H1–2) could fall between A.D. 700 and 900, i.e. around A.D. 800, and five or six (D5, E, I, G1–2) between A.D. 800 and 1000. Because of the difficulty in relating specific radiocarbon dates to finds, such dates have not been used to identify or date any of the vessels. Some sherds have, however, been found close to radiocarbon dated samples (cf. Fig. 3), which may give a further indication whether the suggested date is reasonable or not. One sherd from vessel B was found immediately above sample T–7802 (A.D. 790–900). This sample comes from a hearth in room C, the chronological position of which is still debated. Other samples from the same hearth are T–8255 (A.D. 670–890) and T–8969 (A.D. 685–885). Two sherds from vessel D1 were also found near dated samples, one above T–8972 (A.D. 565–600), and another above T–8973 (A.D. 650–780), from a hearth and the floor layer in room A respectively. In addition, one sherd from vessel C and one from vessel H2 were found above sample T–8973. Finally, the sherd from vessel D5 was found just below sample T–6040 (A.D. 770–970), at the bottom of a wall ditch in one of the trial trenches N.W. of

TABLE 2

DESCRIPTIVE SUMMARY OF BORG VESSELS

Vessel		*Sherds*	*Rim diameter (mm)*	*Body diameter (mm)*	*Colour*	*Decoration*
Soda-lime-glass						
A 1–2	Filigree bowls	2 rim 13 body	120	 90–130	Cobalt blue	Colourless cables, yellow trails
B	Claw beaker	12 body		50–60	Pale blue-green	Self-col. trails and claws
C	Funnel beaker(s)	3 rim 2 base 18 body	130	 50–100	Pale green colourless	Gold foil
D1	Palm cup	3 rim 4 body	85	 50–70	Dark transl. green	
D2	Palm cup	1 rim 9 body	NA	50–80 50–80	Pale green	Mould-blown ribbing
D3	Palm cup or funnel beaker	1 rim 1 body	110	 NA	Dark green	Reddish streaks
D4	Unknown	1 body		NA	Pale blue-green	
D5 D6	Funnel beaker(s)	2 rim	130		Pale green	Reddish streaks
E	Funnel beaker	7 rim 21 body	100		Pale green	Dark streaks
F	Palm cup?	1 rim 1 body	90	 NA	Very pale green	
H1 H2	Palm cups or funnel beakers	1 rim 1 body	110	 50	Pale green Pale green	
I	Cylindrical vessel	1 rim?	60		Olive green	Dark brown trails
J	Inlay?	1			Yellow-green	Notches
Potassium-rich glass						
G1	Funnel beaker?	2 rim 2 body	120	 60–90	Dull-green	Horizontal stripes
G2	Funnel beaker?	7 body		70–90	Dull green	Mould-blown ribbing

House I. Apart from the B sherd from room C, the suggested datings of the other vessels thus *seem* to be supported by the radiocarbon dates, it is, however, difficult to determine whether the connection is real or just coincidental.

Assuming that the dating of the vessels is reasonable, and that examples of all or most vessels used were deposited on the site and recovered during the excavation, the deposition rate is three per century or one per generation, probably with a slight increase in the 8th and 9th centuries. It further suggests that only one or two vessels were new at any one time, and that there was a steady import of glass vessels through the Merovingian and Viking periods. Of the vessel sherds, 95% come from House I, with 75% from the 'guild hall' (room C), 11% from living room A and 5% from storage room D, while 9% are stray finds. Finds from the midden along the W. wall are included as it is difficult to establish whether sherds actually come from the midden or were deposited outside the wall by modern ploughing.

SODA-LIME GLASS

Vessel(s) A1–2: Filigree (reticella) glass (Table 1, analyses 1–7; Fig. 5; Pl. 1, A)

The cobalt blue sherds, most of which are decorated with yellow spiral trails and/or colourless cables with yellow trails, seem to represent at least one bowl of the type found in Valsgärde grave 6,[61] as they include two folded rim sherds with yellow spiral trails inside, a rim type unknown from other vessels.[62] Several different reticella cables have been used, some narrow and only slightly melted into the wall, others wider and better melted. The yellow trailing of the cables also differ.

Similar bowls have been positively identified on several other sites: Ribe, Denmark,[63] Southampton,[64] London, Barking and Brandon, England,[65] Saint-Denis, France,[66] Dorestad, Holland,[67] Åhus,[68] Helgö[69] and probably also at Ingjaldshögen[70] and Slagsta,[71] Sweden, and at Esslingen, Germany.[72] The colour and ornamentation of the Borg vessel(s) is, however, unusual. Näsman[73] only mentions three blue reticella sherds, from Ribe, Denmark, Whitby Abbey, England,[74] and Staraja Ladoga, Russia, and a possible, dark blue sherd from Portchester, England. The ornamentation of the Borg bowl(s) seems to consist of arcs or loops on the lower part of the vessel(s). The pattern is reminiscent of that found on certain Frankish pouch bottles and bowls of the migration period[75] and on later pouch

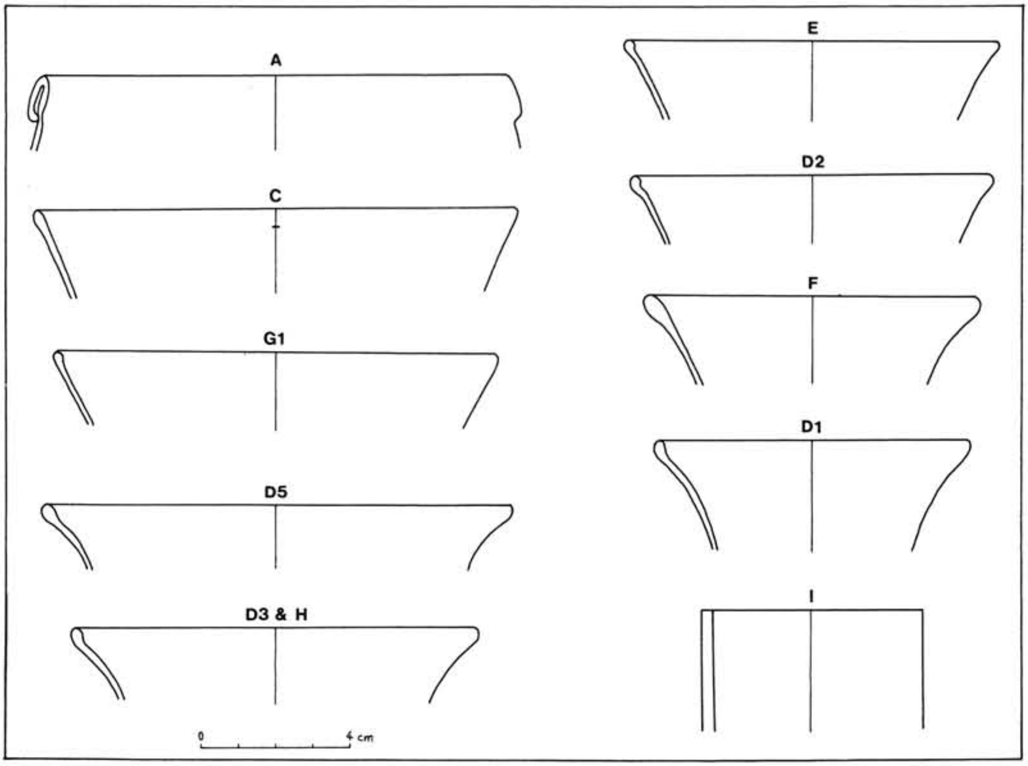

FIG. 5
Rim profiles of Borg vessels. (Drawing by I. Holand)

bottles/squat jars from Scandinavia, England and the Continent,[76] the difference being that these loops are made from self-coloured trails, not reticella cables. Such decoration is mostly unknown from other reticella vessels, where horizontal and/or vertical cables usually form the pattern. There are, however, a few examples with a vague resemblance to the Borg pattern: one sherd from Ribe has a 'slightly curved' cable,[77] another from Southampton has two reticella cables 'die in Bögen ineinandergestellt sind',[78] while one sherd from Portchester has cables forming 'hanging' arcs,[79] and two sherds from Esslingen have 'oblique cables'.[80] Of these only the Portchester and Southampton sherds display arcs, the latter, however, in the form of double arcs.

Valsgärde grave 6, and thus the reticella bowl, was traditionally dated to A.D. 700–750,[81] but Arrhenius[82] has suggested a somewhat earlier date, A.D. 630/40–670/80, based on revised Continental chronologies. This makes the Valsgärde bowl and a sherd from Eketorp[83] the oldest, definitely dated, post-Roman reticella vessel finds.[84] Apart from Helgö with a dating range from the 4th century to the Viking period, and Portchester and London, both dated to the Viking Age, all the finds mentioned above belong to the 8th–9th centuries.[85] Taking into account the colour, too, an 8th- or early 9th-century date for the Borg bowl(s) therefore appears reasonable.

Although reticella decoration is known from Roman glass vessels of the 1st century A.D. it only re-emerges in N.W. Europe in the 6th–7th centuries. In addition to the bowl finds mentioned above, other types of reticella glass are known from three S. Norwegian sites,[86] all from the 8th–9th centuries, and three Swedish or Danish finds.[87] Outside Scandinavia reticella glass has been found mainly in the British Isles,[88] but a few finds also come from Germany,[89] Greece,[90] Italy,[91] and the Ukraine.[92] A number of possible production areas have therefore been suggested: N. France/Belgium,[93] Scandinavia[94] and England,[95] but recent research points to several centres of production.[96] Although some early vessels may originate from England, the excavations at San Vincenzo in Italy show that vessels and reticella cables were also produced in a Mediterranean context in the 9th century. It is thus difficult to say with certainty *where* the Borg vessels were produced, but the general distribution, the blue colour and the arc pattern could well point to England.

Vessel B: Claw beaker (Table I, analyses 8–9; Pl. I, B)

The thin blue-green sherds thought to come from a claw beaker have both self-coloured spiral trailing and narrow, vertical trails applied on top of these, with a distinct groove along the middle. They are interpreted as the lower part of flat claws drawn out with a hook, and thus originating from a beaker of Evison's type 4 or the late Uppland type.[97] Both belong to the last stage in the development of claw beakers in the Merovingian period and are usually tall, conical beakers with claws that are not blown as on earlier types,[98] but drawn out and pressed flat against the sides of the vessel. Among the Uppland beakers only the earliest from Valsgärde 8 has spiral trailing beneath the claws on the lower part of the vessel. Another possibility is therefore a beaker like Vendel XII or Grötlingbo/Hablingbo, i.e. Evison's type 4.[99] The Valsgärde 8 grave was earlier dated to A.D. 750–800.[100] Arrhenius,[101] however, suggests a much earlier date, A.D. 560/570–600, which is accepted by Näsman.[102] The same date is given to Vendel XII, indicating that the Borg glass should be placed in the second half of the 6th century, thus probably making it the oldest of the Borg vessels.

Claw beakers are already common on the Continent and in England during the migration period and have been extensively discussed.[103] Despite a number of Scandinavian finds, there are only three other Norwegian ones. The best known comes from a Viking Age grave at Borre in Vestfold, but the beaker has traditionally been dated to the 5th century.[104] Recently, however, Evison[105] has suggested that it belongs to the 7th or 8th century. The other finds, both claw fragments, come from Kaupang, and so are of the 8th–9th century,[106] and Øygarden in W. Norway, possibly of the Uppland type and thus from the Merovingian period.[107] There is only one Danish find of a type 4 beaker,[108] while Sweden has yielded a number of type 4 and Uppland beakers.[109] All other finds of these beakers come from England or Germany.[110]

While Fremersdorf[111] and Rademacher[112] favoured a Continental production centre, Evison[113] has proposed an English vessel production which already included claw beakers by the 5th century, and that several of the mid 7th-century beakers of type 4, including those found in Sweden, were produced in Kent. This is based partly on distribution, partly on certain ornamental features and the deep blue colour of many of these vessels, which is characteristic of other Kentish vessels. The Uppland beakers probably developed from the Kentish type, suggesting that they, or their maker(s), came from Kent.[114] A Scandinavian production centre was, however, refuted by Arwidsson in 1942, and Näsman[115] also favours an English production. A possible indication of this is the flat claw of blue-green glass with red streaks from Brandon,[116] which is very similar to the red streaked Valsgärde beakers.[117] The Borg vessel could therefore well be of English origin.

Vessel C: Gold glass (Table 1, analyses 10–13; Fig. 6; Pl. II, c)

Probably the most spectacular of the Borg glass are the nearly colourless or slightly greenish sherds, most of which are decorated with applied gold foil in geometric patterns. On all sherds, except two rim sherds and two base sherds, the pattern is recognizable either by preserved gold foil or traces in the glass surface showing where it was applied. Only some of the sherds fit together, making both vessel and pattern reconstruction difficult. Slight discrepancies in the chemical composition might suggest the presence of two different vessels, which must, however, have been nearly identical in form, size and decoration. The reconstructed form is based on the rim and base sherds, as well as the space needed for the

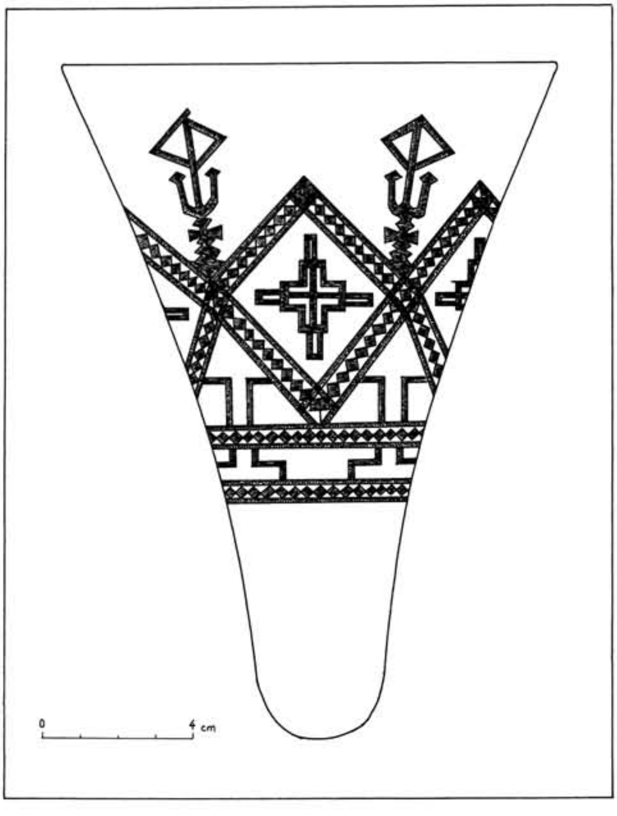

FIG. 6
Possible reconstruction of gold decorated vessel C. (Drawing by I. Holand)

proposed pattern (Fig. 6). The form is thought to resemble closely that of an early funnel beaker from Birka,[118] but is slightly bigger.

The gold foil pattern has been reconstructed using the diameter of individual sherds to determine their relative position and then adding overlapping sections to build up the proposed pattern. The pattern elements present consist of a central cross motif, diagonally framed by double lines with rows of lozenges in between, probably repeated four times around the vessel. Parts of four crosses have been found. Below this, two horizontal sets of double lines with lozenges frame a simple geometric pattern. Most uncertain is the top with its vertical, 'candlestick' motif. This is found on two sherds, while another, fitting at the top end of one of them, suggests the addition of the large, open lozenge shape on top. Despite all three being the same size only one rim sherd shows traces of an oblique upper part of the pattern, possibly indicating that only parts of the pattern reached as far up as this.

No other gold decorated glass has been found in Norway, but a few sherds have appeared on nine other sites in Scandinavia and elsewhere in N.W. Europe.[119] Most have pattern traces reminiscent of certain elements on the Borg glass, like lines, lozenges and triangles, while the cross and 'candlestick' motifs are unknown elsewhere. Closest to the Borg pattern is a sherd from Dorestad with diagonally crossing framed bands of lozenges and triangles.[120] It is from a palm cup or funnel beaker somewhat smaller than the Borg beaker, but described as colourless with a slight yellowish tinge; both form and colour are therefore similar to the Borg beaker. The Dorestad beaker, however, has diagonal bands continuing right up to the rim. Apart from some Swedish sherds which are tentatively dated to the migration period,[121] all other finds date between A.D. 700 and 900, most of them probably to the late 8th century. A date between A.D. 750 and 850 therefore seems a reasonable estimate for the Borg vessel, also taking into account the form.[122]

As finds of gold foil decorated glass from the Merovingian and Viking periods are so few, Lundström's 20-year-old article[123] still forms the most comprehensive discussion of this unusual type of glass. Earlier types of gold glass are, however, known from Italian finds of the 3rd–1st century B.C., which on stylistic grounds are believed to be of Egyptian origin.[124] Here the gold foil pattern was sandwiched between two layers of transparent glass, so-called 'Zwischengoldglas', as is the case for the younger and probably best known group of gold glass, the 3rd–4th century A.D. medallions with portraits or Christian motifs, which are thought to have been produced in Italy.[125] Still more interesting in our context, however, is a contemporary group of gold glass found in the Rhineland, where the gold decoration was not protected by an outer glass layer.[126] The oldest examples date to the first half of the 4th century[127] and were probably found and perhaps also produced in the Köln area. They are decorated with pictorial scenes in gold foil, as well as other decorations.[128]

The late group of gold glasses nearly all have patterns consisting of geometric figures, usually lines, triangles and lozenges. The only finds to differ are, interestingly enough, the three Swedish finds tentatively dated to the migration period. Helgö has yielded two different types of gold glass, one blue with small triangles in gold foil, similar to most of the late Continental finds, the other a light green glass with a pattern of pointed arcs. A similar pattern is found on the Valsgärde sherds, making them more reminiscent of etched or engraved ornamentation on 4th–/5th-century glasses.[129] According to Hunter[130] the Torslunda sherds have gold foil covering a large area, also an unusual feature. The Valsgärde sherds, however, seem to display lozenge bands in addition to the arcs, and as the Borg sherds contain several pattern elements unknown elsewhere, the existence of unique elements is probably not in itself a reliable dating indicator. It could as easily be due to our present limited knowledge about these glasses.

The discussion of how the gold foil was applied to the glass surface has mainly dealt with Zwischengoldglas, which does not necessarily demand a binding agent to keep the gold foil in place. For glasses without a protective glass layer Harden[131] refers to Fremersdorf who, while discussing the early pictorial gold glasses with incised lines, suggested that 'the whole surface was covered with thin gold leaf into which the pictures were drawn with a fine point while the background was engraved free-hand with a point'. Reheating to a high temperature bound the gold foil to the glass surface, while 'different expansion of the glass and the gold led to numerous small cracks in the gold leaf'. Doppelfeld, on the other hand, suggested a binding agent, perhaps egg-white, which 'was applied to the parts of the glass which were to be gilded'. The drawing was scratched into the fresh glass with a wooden point before the gold foil was applied and reheated. The cracks in the gold foil were produced by the binding agent, and after reheating the gold foil was wiped off the surfaces where no agent had been applied.

A characteristic feature of the late gold glasses is that the pattern is recognizable even where the gold foil itself is lost. On the Borg glass the pattern outline is marked by thin lines, while the pattern itself is filled by slightly coarser lines or cracks. It is possible that these internal lines were made by engraving, either to hold a binding agent or the foil itself, but considering the intricacy, size and detail of the pattern this would seem a daunting task. Another possibility is that the lines are the result of a reaction between the glass surface and some other medium. The method suggested here is that the whole surface was originally covered with a binding agent, the gold foil then applied, and the pattern cut through both. Gold foil and binding agent were then removed from areas that would eventually appear clear, before the glass was reheated. This removal could explain the fine scratches and lines on clear pattern areas on the Borg glass. During reheating the binding agent reacted with the glass surface to produce the fine cracks underneath and in the gold foil.

Of 33 sherds known outside Borg, 22 are light green (Dorestad, Liège, Helgö, Valsgärde), two yellowish-brown (Paderborn), two colourless (Dorestad, Åhus) and five blue-dark blue (Dorestad, Liège, Niedermünster, Helgö), while colour is unknown for the sherds from Torslunda and Ribe. Baumgartner and Krueger's view[132] that light green gold glasses seem to be much rarer than blue ones, is therefore unlikely. Five sherds come from cylindrical vessels (Paderborn, Liège and Helgö) and five from funnel beakers (Dorestad, Liège), the other 23 from unknown vessel types. The existence of several cylindrical or slightly convex vessels, a form otherwise unusual, is noticeable and led Lundström to compare them to early Christian chalices.

Lundström[133] suggested a connection between the gold glass and the first Christian missions to Scandinavia. This was based on a comparison of gold glass with tin-foiled pottery, the so-called Frisian or Tating ware, which is often decorated with a cross symbol in addition to geometric patterns. These jugs had already been interpreted as liturgical vessels by Selling[134] and Liestøl,[135] the latter suggesting that they were part of a set for liturgical handwashing consisting of a hanging bowl and a jug. Lundström also mentioned[136] two vessels described in a 9th-century text as 'cuppas vitreas auro ornatas', which from the context must be interpreted as liturgical vessels. Gold decorated glass vessels are also mentioned in other written sources from the same century. Lundström therefore concluded that both Tating ware and gold glass 'have distinct connexion with an ecclesiastical environment' and may be 'regarded as evidence of the earliest Christian mission in Sweden'. Both have also mainly been found in market places which were the natural mission centres, or connected with Christian structures.[137]

Selling[138] had further interpreted a figure sometimes found on Tating ware, which consists of a triangle and a lozenge, as a stylized fish, another Christian symbol. The same figure appears on a number of gold glasses (at Helgö and Paderborn, which were known to Lundström, as well as Liège, Dorestad, and Niedermünster), and Lundström regarded this, too, as a link not only with the pottery, but also with a Christian context. It is difficult now to accept this interpretation of the motif, partly because of the dimensions which in most cases leave the 'fish' with a small body and a much larger tail, and partly because the motif on one of the Dorestad sherds is made up of a triangle with a rectangle at its tip. The figure does not appear on the Borg sherds, which instead seem to have crosses as their central element. They are, however, quite different from the Greek crosses found on Tating ware.

Selling[139] also suggested that the Tating jugs were produced in the Benedictine monastery at Lorsch in Rhineland, where the 'stylized fish' pattern is found as wall decoration. It also occurs on other objects, like the so-called pseudocameo fibulae,[140] which have been found in the Rhine area of Germany and Holland[141] and seem to date to the

8th–9th centuries A.D. and on an iron shield boss covered with bronze foil from Morken near Köln, dated around A.D. 600. All are thought to be Rhenish products and show that the pattern and the technique of foil decoration were known in the area in the 8th century. Lundström[142] therefore agreed that the pottery and probably also the glass was produced in the Rhine area, but both the pseudocameos and the pottery show influences from Lombardic Italy.

Baumgartner and Krueger[143] reject Lundström's interpretation of the gold glasses as chalices because of the diversity in forms and regard them instead as luxurious drinking glasses. Evison,[144] however, accepts Lundström's theory and a production centre at Lorsch as the most likely, although Paderborn, with its evidence for vessel production,[145] should not be ruled out. The Christian connections of both Tating ware and gold glass seem quite plausible, and the combination of gold glass, Tating ware and a hanging bowl found at Borg is very suggestive. The existence of such objects on a site should not, however, be interpreted as proof of Christian activity at that particular site, they are more likely to be objects of ritual significance in Christian contexts, which have been transferred to a pagan context emulating certain aspects of the Christian rituals.

Vessels D1–6, E, F & H1–2: Light green palm cups and funnel beakers[146] (Table 1, analyses 14–25; Fig. 5; Pls. I, D; III, A)

Th oldest vessels from this group are probably D1 and D2, both thought to date from the 7th century. D1 (analysis 14) is a translucent green palm cup, probably similar to Rademacher 1942, Taf. 58–59, while D2 (analyses 15–17) with its finely ribbed body sherds (Pl. I, C) is thought to be a wide palm cup like Rademacher 1942, Taf. 55:2. A possible elongated palm cup, F (analysis 23), may date to the 8th century. It is very light green with a profusion of bubbles and tiny, black impurities in the glass. Two or three vessels are thought to be late palm cups or early funnel beakers, probably from the 8th–9th centuries. D3 (analysis 18) is a green vessel, and though the sherds are weathered, the chemical analysis showed the metal to be soda-lime glass. Two light green vessels, H1–2 (analyses 24–25), have been identified as different from the others, but similar to each other through the chemical analysis.

The best-preserved Borg vessel, E (analysis 22), is a light green funnel beaker of which the upper half could be reconstructed (Pl. III, A). It may date to the 9th century. Sherds D5–6 (analyses 20–21) probably represent two different light green vessels, as D5 is the only sherd from a stratified context outside House I. The profile of both sherds seems to indicate a late funnel beaker, probably from the 9th–10th centuries. Yet another vessel of the same chemical composition as most of the light green palm cups/funnel beakers, D4 (analysis 19), is represented only by a tiny, light bluish-green sherd, visually more similar to the claw beaker sherds. It is too small and nondescript to allow any identification of form.

Palm cups and funnel beakers are usually simple undecorated vessels, but some display ornamentation like mould-blown ribbing, applied trails, reticella or gold foil decoration, applied rims in contrasting colour, or streaks in a different colour. They have been found in large numbers both on the Continent and in England, and without characteristic decoration it is difficult to decide where they were produced. Apart from the gold foiled funnel beaker (C) discussed above, the Borg beakers comprise two ribbed vessels, thought to represent both extremes of the chronological span (D2 and G2 below), but no other deliberate decoration. Vessel E has arc-like 'threads', reminiscent of the pattern on some funnel beakers from Birka,[147] but not forming a regular pattern and which can therefore be regarded as random faults rather than consciously applied trails. Four vessels do, however, display reddish streaks in the glass metal, a feature which has been much discussed in connection with claw beakers. Fairly broad streaks are found on the rim sherd from vessel D3, while D5 and E have faint, hair-like streaks and D1 clear streaks. All belong to the same chemical group.

Red-streaking is also found on the Valsgärde and one of the Vendel claw beakers, and was first discussed by Arwidsson.[148] Later Arbman[149] briefly mentioned the feature in connection with finds from Birka, Dorestad and Cordel, expressing doubt that glass with prominent layers of red, like the Valsgärde 5 beaker, and glass with only faint reddish streaks like the Valsgärde 6 beakers, should be considered 'technisch und kulturgeschichtlich' as belonging to the same group. In his view the first group showed deliberate use of red as an ornamental feature, while the streaks found in the second group were merely accidental.

The feature has later been discussed also by Evison.[150] Apart from the Brandon claw mentioned above, English finds of red-streaked glass include window glass from the monasteries of Monkwearmouth and Jarrow, Whitby, Repton, a couple of vessel sherds from Southampton and Northampton and window glass from Lurk Lane, Beverley.[151] Evison seems to consider[152] it a deliberately created bi-coloured effect, a technique supposedly introduced into N.W. Europe at the end of the 7th century, both for vessel and window glass. Another indication of this change in production techniques was a change in basic colours, from the naturally coloured glass of the early Merovingian period to strong, deliberately created colours, like dark green and clear blue[153] in the later part of the period. This may have been the result of a demand for coloured window-glass in churches. Both Arwidsson and Evison regard the changes as a result of transference of knowledge from elsewhere, possibly Italy or other parts of the Mediterranean area. Arrhenius's[154] revised dating of the Valsgärde and Vendel graves, however, places the phenomenon somewhat earlier than Arwidsson and Evison envisage, before A.D. 670/680. The red-streaked Borg glasses seem to date from the 7th to the 9th century, but whether they, like the red-streaked claw beakers, should be connected with England, must remain an open question. Heyworth[155] has recently suggested that Rhineland could be a possible principal centre for the manufacture of palm cups and funnel beakers, based on detected impurity patterns.

Sherds I–J: Cylindrical vessel and ?inlay (Table 1, analyses 26–28; Fig. 5; Pl. III, B)

The chemical analysis shows a strong similarity between these two sherds, and a composition which probably dates to the Viking Age. Sherd I (analyses 26–27) comes from a cylindrical vessel. The thick, olive-green glass with a few, tiny bubbles has two wide and flat, vertically applied trails in dark brown with several elongated bubbles. One edge of the sherd forms a semicircle and may be interpreted as a sloping rim. Sherd J (analysis 28) does not represent a vessel, but probably the edge of a flat inlay. It has a sharp edge towards the underside and a slightly rounded edge towards the surface, of which only a narrow strip has been preserved. The glass is yellowish-green with a lot of bubbles.

POTASSIUM-RICH GLASS

Vessels G1–2: Funnel beakers? (Table 1, analyses 29–34; Fig. 5; Pl. III, C)

Several dull green sherds were identified visually as being different from the rest, but possibly representing two vessels. This was confirmed by the chemical analysis, which showed both vessels to be in potassium-rich glass of an unusual composition. Vessel G1 (analyses 29–30) has faint, horizontal stripes on the outer surface below the rim, possibly from polishing, while G2 (analyses 31–34) has wide, vertical ribbing.

The chemical composition again suggests a Viking Age date,[156] and the vessels *may* be fairly large funnel beakers, as indicated by the rim profile of G1. There are not, however, many examples of ribbed funnel beakers and, to our knowledge, none in potassium-rich glass. A light green beaker from Birka grave 493 is described as having 'ebenen Flächen schwach fazettiert ... die Fazettierung nur bei gewissen Lichtbrechungen sichtbar',[157] while some nearly colourless sherds from Birka grave 942 represent a funnel beaker 'mit schwacher Fazettierung'.[158] The photo shows them to have distinct, but narrower ribbing than the Borg sherds. Finally, from Dorestad comes a bluish-green rim sherd with 'faint, premoulded ribs'.[159] Based on their observed durability none of these seem to be in potassium-rich glass.

The only possible example of a ribbed vessel of potassium-rich glass is a flat flask from a 10th-century grave at Broa, Gotland, described by Arbman as having 'Fäden ... von dem Hals nach unten gezogen, ziemlich stark eingeschmolzen und platt gedrückt'.[160] The illustration, however,[161] suggests that mould-blown ribbing is as likely an explanation. The flask is bluish-green, and a chemical analysis carried out for Arbman[162] showed a composition somewhat different from the Borg glass. The possibility that the Borg sherds represent earlier, wide bowls of the type Rademacher 1942, Taf. 55:1, as initially thought, cannot therefore be totally dismissed.

THE LOCAL CONTEXT AND FOREIGN CONTACTS

The site excavated at Borg has repeatedly been interpreted as the remains of a chieftain's farm, with Borg/Bøstad as one of two main centres on the island of Vestvågøy in the first millennium A.D. It is therefore interesting to have a written account which provides a description of the type of chieftain who may have resided at Borg, as well as of the contacts between N. Norway, England and the Continent in the Viking period. This is the account by the N. Norwegian chieftain Ottar (Ohthere) to King Alfred the Great of his home and long travels. Ottar visited Alfred's court around A.D. 890, and the king found his account so fascinating that it was included in an English translation of Orosius's history of the world.[163]

It is not known exactly where Ottar lived, but he claimed to live the furthest north of all Norwegians. The land, however, continued far beyond, but then as a wilderness inhabited only by a few Saami[164] hunters and fishermen. This places Ottar somewhere in the county of Troms, i.e. even further N.E. than the Lofoten Isles. Although Ottar owned a farm where he kept horses, cows, sheep and pigs and also ploughed the land, this could not have provided the wealth and power which enabled him to undertake journeys like the one to England. His main source of income was probably the revenue collected from the Saami population in the form of furs, hides, feathers, whale bone, and ship ropes made from seal and whale hides. He also owned several hundred reindeer.

Ottar's journeys had taken him E. into the White Sea where he traded with the Biarmas and S. along the coast of Norway to Sciringesheal, now known as Kaupang, in the Oslo Fjord, and from there to Hedeby and eventually England. His cargo probably consisted of goods collected from the Saami or bought from the Biarmas, such as furs and walrus tusks, to be sold as luxury articles in Europe or brought as precious gifts to kings like Alfred. In return Ottar brought back necessities like grain, but also exotic objects such as fine textiles, weapons, jewellery, glass and pottery, as well as new ideas and influences.

The excavations at Borg show that at least the import of glass vessels to this distant part of Scandinavia was well established long before Ottar made his journey to England and continued all through the Merovingian and Viking periods. They also show that the relatively small numbers of imported objects in N. Norwegian graves of the period probably does not reflect the true amount of imports. For instance only one glass vessel from the period has been found in a N. Norwegian grave.[165]

The glass finds from Borg are consequently surprising and important in many respects. They include vessel types, ornamentations and compositions which are rare or even unknown elsewhere, and thus add to our general knowledge of early medieval glass in a European context. At the same time they demonstrate the extent of contacts with the Continent and England during this period. How these contacts should be interpreted: as gift exchange, or indirect or direct trade, is still unclear, as is the role and function of objects like glass vessels and Tating ware pottery within the local context.

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APPENDIX

SUMMARY OF RADIOCARBON DATES

All analyses were carried out at Laboratoriet for Radiologisk Datering, Trondheim, Norway. Calibrations of dates to calendar years quoted at 1 sigma level of probability (68%).[166]

	Lab. No.	Years B.P.	Pearson and Stuiver cal.
1.	T-5443	1300 ± 70	A.D. 660–780
2.	T-5444	1710 ± 50	A.D. 250–400
3.	T-6040	1170 ± 80	A.D. 770–970
4.	T-6436	1790 ± 70	A.D. 130–260
5.	T-6437	1060 ± 70	A.D. 890–1030
6.	T-7084	990 ± 70	A.D. 990–1150
7.	T-7085	1370 ± 70	A.D. 620–680
8.	T-7799	1570 ± 80	A.D. 410–590
9.	T-7800	1360 ± 80	A.D. 630–690
10.	T-7801	1140 ± 100	A.D. 780–1000
11.	T-7802	1140 ± 80	A.D. 790–990
12.	T-7803	1200 ± 60	A.D. 730–890
13.	T-7804	1110 ± 100	A.D. 790–1010
14.	T-8255	1240 ± 80	A.D. 670–890
15.	T-8969	1225 ± 65	A.D. 685–885
16.	T-8970	1785 ± 70	A.D. 130–335
17.	T-8971	1290 ± 45	A.D. 670–775
18.	T-8972	1425 ± 65	A.D. 565–660
19.	T-8973	1315 ± 80	A.D. 650–780
20.	T-8974	1565 ± 135	A.D. 340–630
21.	T-8978	1460 ± 80	A.D. 540–655
22.	T-8979	1580 ± 80	A.D. 400–565

NOTES

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[13] I. Holand, 'Finds distribution and function analysis', in *Borg, a North-Norwegian Chieftain's Farm in the Iron Age* (forthcoming).
[14] Stamsø Munch, op. cit. in note 9.
[15] Holand, op. cit. in note 13.
[16] A fuller description of the finds, their analysis and interpretation is presented in Holand, op. cit. in note 13. Selected groups of finds are discussed in more detail by different scholars in the same publication.
[17] Holand, op. cit. in note 13.
[18] Stamsø Munch *et al.*, op. cit. in note 1, figs. 11–12.
[19] Ibid., fig. 10.
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[43] J. Henderson, 'The glass', in P. Armstrong *et al.*, *Excavations at Lurk Lane Beverley 1979–92* (Sheffield Excavations Reports, 1, 1991), 124–30, fiche B6–C1.

[44] J. Henderson, 'Archaeological and scientific analysis of the glass from Peel', in D. Freke, *Excavations at Peel Castle, Isle of Man* (University of Liverpool Monograph) (in press).

[45] V. I. Evison, 'The Vendeuil Caply glass horn', *Nord-Ouest Archeologie*, 3 (1990), 89–96; M. Heyworth, 'Analysis of glass vessel fragments from Vendeuil, France', *Nord-Ouest Archeologie*, 3 (1990), 97–98.

[46] H. Lundegårdh, 'Chemische Analysen von Glas aus der vorgeschichtlichen Zeit und dem frühen Mittelalter', Exkurs in H. Arbman, *Schweden und das karolingische Reich* (1937), 251–55; V. I. Evison, 'Red marbled glass, Roman to Carolingian', *Annales du 11e Congrès de l'Association International pour l'histoire du verre*, Basel, 1988 (1990), 217–18.

[47] J. Henderson, 'Scientific analysis of the glass from Ribe, Jutland' (forthcoming).

[48] M. Dekówna, 'Untersuchungen an Glasfunden aus Haithabu', *Das archäologische Fundmaterial V* (Neumünster, 1990), 9–64.

[49] Ibid., table 13.

[50] C. Isings, 'Glass finds from Dorestad, Hoogstraat I', in W. A. van Es and W. J. H. Verwers (eds.), *Excavations at Dorestad, 1: The Harbour: Hoogstraat 1* (1980), 225–37.

[51] M. Dekówna, 'Remarques sur la chronologie de l'introduction dans la verrerie europénne mediévale de la technologie potassique et de celle au plomb non-alkaline', *Annales de 8e Congrès de l'Association Internationale pour l'Histoire du verre*, London–Liverpool 1979 (Liège, 1981), 145–60.

[52] S. Loeschke, 'Zur angeblich römisches Glashütte auf der Hochmark b. Cordel', *Römisch-Germanisches Korrespondenzblatt*, 8 (1915), 49–57; H. Arbman, *Schweden und des karolingische Reich* (1937).

[53] Evison, op. cit. in note 46.

[54] Lundegårdh, op. cit. in note 46.

[55] Unpublished analyses by J. Henderson.

[56] T. E. Haevernick, 'Karolingisches Glas aus St. Dionysius in Esslingen', *Forschungen und Berichte der Archäologie des Mittelalters in Baden-Württemberg*, 6 (1979), 157–71.

[57] J. Henderson and M. Mango, 'Iconographic and scientific analysis of glass from the Catacombs in Rome' (forthcoming).

[58] D. C. W. Sanderson and J. R. Hunter, 'Neutron activation analysis of archaeological glass from Britain and Scandinavia', *PACT*, VII (1982), 401–11.

[59] E.g. compare Sanderson *et al.*, op. cit. in note 35.

[60] J. Henderson, 'Electron probe microanalysis of the cables', in J. R. Hunter and M. Heyworth, *The glass from Hamwich* (in press).

[61] G. Arwidsson, *Die Gräberfunde von Valsgärde, I: Valsgärde*, 6 (1942).

[62] Slight discrepancies between these two sherds led U. Näsman to suggest that they came from different vessels, a conclusion not supported by the chemical analysis; see Näsman, 'Vendel period glass from Eketorp-II, Öland, Sweden. On glass and trade from the late 6th to the late 8th centuries A.D.', reprinted from *Acta Archaeologica*, 55 (1984) (1986), 79.

[63] Ibid.

[64] E. Baumgartner and I. Krueger, *Phönix aus Sand und Asche. Glas des Mittelalters* (München, 1988), 76.

[65] V. Evison, 'Some Vendel, Viking and Saxon glass', in B. Hårdh *et al.* (eds.), *Trade and Exchange in Prehistory. Studies in Honour of Berta Stjernquist* (Acta Archaeologica Lundensia, Series IN 8°, no. 16, 1988), 241; L. Webster and J. Backhouse (eds.), *The Making of England. Anglo-Saxon Art and Culture A.D. 600–900* (1991), 92–93.

[66] N. Meyer and M. Wyss, 'Fragments de verre colores', in D. Foy and G. Sennequier (eds.), *A travers le verre, du moyen âge à la renaissance* (1989), 145.

[67] Isings, op. cit. in note 50, 231; Baumgartner and Krueger, op. cit. in note 64, 71.

[68] J. Callmer, 'Production site and market area', *Meddelanden från Lunds universitets historiska museum, N.S.* 4 (1982), 149; J. Callmer, 'Vendeltida glasmästere på handelsplatsen i Åhus', *Populär Arkeologi*, 8/3 (1990), 20.

[69] W. Holmqvist, 'Glass', in W. Holmqvist and B. Arrhenius (eds.), *Excavations at Helgö II. Report for 1957–1959* (1964), 250–51; Näsman, op. cit. in note 62, 77.

[70] Näsman, op. cit. in note 62, 75–76.

[71] A. Bennett, 'Gravfält och fynd från järnåldern. En kort översikt över 1970–71 års utgrävningar i Botkyrka', *Fornvännen*, 67 (1972), 247 ff.; Näsman, op. cit. in note 62, 77.

[71] Haevernick, op. cit. in note 56, 157.

[73] Näsman, op. cit. in note 62, 78–80.

[74] The Whitby sherd may come from the wall of a bowl, but was secondarily prepared for use as an inlay (see Holmqvist, op. cit. in note 69, 252; Webster and Backhouse, op. cit. in note 65, 143).

[75] F. Rademacher, 'Fränkische Gläser aus dem Rheinland', *Berliner Jahrbuch*, 147 (1942), Taf. 64:1, 65:2.

[76] Näsman, op. cit. in note 62, 70, also fig. 7.7.
[77] Ibid., 78.
[78] Baumgartner and Krueger, op. cit. in note 64, 75, no. 21.
[79] Näsman, op. cit. in note 62, 79.
[80] Haevernick, op. cit. in note 56, 157; Näsman, op. cit. in note 62, 79.
[81] Arwidsson, op. cit. in note 61.
[82] B. Arrhenius, 'The chronology of the Vendel graves' in J. P. Lamm and H.-Å. Nordström (eds.), *Vendel Period Studies. The Museum of National Antiquities, Stockholm Studies*, 2 (1983), 44.
[83] Eketorp is thought to have been abandoned around A.D. 650, cf. Näsman, op. cit. in note 62.
[84] Ibid., 80.
[85] Näsman, op. cit. in note 62, 76–80, with further references; Evison, op. cit. in note 65, 241; Meyer and Wyss, op. cit. in note 66, 145.
[86] Kaupang, Hougen, op. cit. in note 25, 119; Hopperstad and possibly Breviksstranden: E. K. Hougen, 'Glassbegre i Norge fra sjette til tiende århundre', *Viking* (1968), 93, 100.
[87] Birka: Arbman, op. cit. in note 52, 52, and Holmqvist, op. cit. in note 69, 251; Århus: Näsman, op. cit. in note 62, 78; Sorte Muld at Bornholm: U. Näsman, 'Om fjärrhandel i Sydskandinaviens yngre järnålder. Handel med glas under germansk järnålder och vikingatid', *Hikuin*, 16 (1990), 98.
[88] Bedfordbury: V. E. Evison, 'Le verre carolingien', in Foy and Sennequier, op. cit. in note 66, 140; Ipswich: V. E. Evison, 'Anglo-Saxon glass claw-beakers', *Archaeologia*, 107 (1982), 11; Brough of Birsay, Mote of Mark, Repton and Wicken Bonhunt: Näsman, op. cit. in note 62, 79–80.
[89] Runde Berg bei Urach: Evison, op. cit. in note 65, 241; Haithabu: Haevernick, op. cit. in note 56, 157–58; Zähringer Burgberg and Starigard/Oldenburg: Baumgartner and Krueger, op. cit. in note 64, 69; Paderborn: M. Müller-Wille, Westeuropäischer Import der Wikingerzeit in Nordeuropa', in S.-D. Lindquist (ed.), *Society and Trade in the Baltic during the Viking Age*, Papers of the VIIth Visby Symposium, Gotland's Historical Museum, Visby, August 15–19, 1983 (1989), 79–102.
[90] Corinth: Evison, op. cit. in note 88, 140.
[91] Ibligo-Invillino and Roma: Näsman, op. cit. in note 62, 80; San Vincenzo al Volturno: Evison, op. cit. in note 65, 243; R. Hodges and J. Mitchell, 'The glass-makers in San Vincenzo', *Current Archaeol.*, 122 (1990), 86–90.
[92] Belgorod Djnestrovski: Haevernick, op. cit. in note 56, 159.
[93] G. Arwidsson, 'Some glass vessels from the boat-grave cemetery at Valsgärde', *Acta Archaeologica*, 3 (1932), 265; Holmqvist, op. cit. in note 62, 252.
[94] Haevernick, op. cit. in note 56, 161.
[95] Näsman, op. cit. in note 62.
[96] Baumgartner and Krueger, op. cit. in note 64, 69; Evison, op. cit. in note 65, 240–42; Näsman, op. cit. in note 87, 98.
[97] Evison, op. cit. in note 88, 50–51.
[98] For a summary of the extensive discussion on the technical creation of claws, see Näsman, op. cit. in note 62, and Evison, op. cit. in note 88, 43 f., both with further references.
[99] Näsman, op. cit. in note 62, 63–65.
[100] G. Arwidsson, *Die Gräberfunde von Valsgärde II: Valsgärde*, 8 (1954), 140; G. Arwidsson, *Valsgärde*, 7 (1977), 126 ff.
[101] Arrhenius, op. cit. in note 82.
[102] Näsman, op. cit. in note 62, 64.
[103] For instance: F. Fremersdorf, 'Zur Geschichte des fränkischen Rüsselbechers', *Wallraf-Richartz-Jahrbuch*, Bd. II/III 1(1933/34); Rademacher, op. cit. in note 75; Evison, op. cit. in note 88.
[104] Evison. op. cit. in note 88, 47, type 2b.
[105] Evison, op. cit. in note 65, 239.
[106] Hougen, op. cit. in note 25, 121.
[107] Hougen, op. cit. in note 86, 88.
[108] Sorte Muld on the island of Bornholm: Näsman, op. cit. in note 87, 97, fig. 5.
[109] Finds of type 4 beakers come from Grötlingbo/Hablingbo, Vendel XII and Vallstenarum, possibly also Sörhusby, Husby–Årlinghundra, Rinkeby, Täby and Helgö, of Uppland beakers from Valsgärde 5, 6 and 8 and Vendel I. See Näsman, op. cit. in note 62, 67–68.
[110] English finds include: Ashford, Faversham (2), Gilton, and Wickhambreux, all Kent, Loveden Hills, Lincolnshire, Taplow, Buckinghamshire (4), and Brandon, Suffolk. The German beakers come from Nettersheim and Siersdorf, but both are probably produced in England. See Evison, op. cit. in note 88 and in note 65, 239; V. E. Evison, 'Some distinctive glass vessels of the post-Roman period', *J. Glass Studs.*, 25 (1983), 89; Näsman, op. cit. in note 62, 68.
[111] Fremersdorf, op. cit. in note 103.
[112] Rademacher, op. cit. in note 75.
[113] Evison, op. cit. in note 88; see also Evison, op. cit. in note 110.
[114] Evison, op. cit. in note 88, 58–59, and in note 110, 89.
[115] Näsman, op. cit. in note 62, 70, and in note 87, 96.
[116] Evison, op. cit. in note 110, 90.
[117] G. Arwidsson, *Vendelstile, Email und Glas im 7.–8. Jahrhundert* (1942), 89 ff.
[118] H. Arbman, *Birka I: Die Gräber. Text/Tafeln* (1953), Taf. 191:1, grave 464.
[119] Sweden: Åhus, see Callmer, op. cit. in note 68, 149; Helgö, see Holmqvist, op. cit. in note 69, 137, 247; Valsgärde, see A. Lundström, 'Cuppa vitrae auro ornata', *Antikvariskt Arkiv 40/Early Medieval Studies*, 3 (1971),

52–53; Torslunda, see J. Hunter, *Scandinavian Glass Vessels of the First Millennium A.D. Typological and Physical Examination* (Ph.D. Thesis, Dept. of Archaeology, University of Durham, 1977), 292; Denmark: Ribe, J. Henderson, pers. comm.; Germany: Paderborn, see W. Winkelmann, 'Archäologische Zeugnisse zum frühmittelalterlichen Handwerk in Westfalen', *Frühmittelalterliche Studien*, 11, Band (1977), 123, and Baumgartner and Krueger, op. cit. in note 64, 66; Niedermünster, see Haevernick, op. cit. in note 56, 165; Holland: Dorestad, see Baumgartner and Krueger, op. cit. in note 64, 66, 68, and Isings, op. cit. in note 50, 230; Belgium: Liège, see Evison, op. cit. in note 65, 240, and V. E. Evison, 'Vieux-Marche, Place Saint-Lambert, Liège — the glass', in M. Otte, Les Fouilles de la Place Saint-Lambert a Liège 2, le vieux marche', *Études et récherches Archéologiques de l'Université de Liège*, 13 (1988), 216–18.

[120] Baumgartner and Krueger, op. cit. in note 64, 66, no. 8.

[121] Helgö, see Holmqvist, op. cit. in note 69, 248; Torslunda, see Hunter, op. cit. in note 119, 292. I. Holand also thanks Else Nordahl, Uppsala University, for access to the unpublished Valsgärde sherds and for explaining their difficult context.

[122] Birka grave 464 is dated to the first half of the 9th century, cf. Arbman, op. cit. in note 52, 39.

[123] Op. cit. in note 119.

[124] K. S. Painter, 'Group K: Gold Glass', in D. B. Harden (ed.), *Glass of the Caesars* (1987), 262–63.

[125] Ibid., 265 ff. See also Henderson and Mango, op. cit. in note 57.

[126] Painter, op. cit. in note 124, 263 ff.

[127] Harden, see note 124, 253, 25.

[128] Ibid., 27.

[129] Holmqvist, op. cit. in note 69, 248; Lundström, op. cit. in note 119, 53.

[130] Hunter, op. cit. in note 119.

[131] Painter, op. cit. in note 124, 26.

[132] Baumgartner and Krueger, op. cit. in note 64, 66.

[133] Lundström, op. cit. in note 119.

[134] D. Selling, 'Problem kring vikingatida keramikkannor', *Fornvännen*, 46 (1951).

[135] A. Liestøl, 'The hanging bowl, a liturgical and domestic vessel', *Acta Archaeologica*, 24 (1953).

[136] Lundström, op. cit. in note 119, 58–59.

[137] Selling, op. cit. in note 134; Lundström, op. cit. in note 119, 57.

[138] Selling, op. cit. in note 134.

[139] D. Selling, *Wikingerzeitliche und frühmittelalterliche Keramik in Schweden* (1955).

[140] Lundström, op. cit. in note 119, 62 ff.; Haevernick, op. cit. in note 56, 163 ff.

[141] Ibid., at Mainz, Mertloch, Esslingen, Strassbourg, Putten and Dorestad.

[142] Lundström, op. cit. in note 119.

[143] Baumgartner and Krueger, op. cit. in note 64. 65.

[144] Evison, op. cit. in note 65 and 199.

[145] Winkelmann, op. cit. in note 119, 123–25.

[146] The typology, development and dating of palm cups and funnel beakers follows Rademacher, op. cit. in note 75, and D. B. Harden, 'Ancient glass, III: post-Roman', *Archaeol. J.*, 123 (1972), 78–117.

[147] Arbman, op. cit. in note 118, Taf. 189:1, 190:2.

[148] Arwidsson, op. cit. in note 93, 259–60.

[149] Arbman, op. cit. in note 52, 70.

[150] V. E. Evison, 'Bichrome glass vessels of the seventh and eighth centuries', *Studien zur Sachsenforschung*, 3 (1982).

[151] Ibid., 15; Henderson, op. cit. in note 43.

[152] Ibid., 19.

[153] Arwidsson, op. cit. in note 117, 93; Evison, op. cit. in note 110, 89.

[154] Arrhenius, op. cit. in note 82.

[155] M. P. Heyworth, *An Archaeological and Compositional Study of Early Medieval Glass from North-west Europe* (Ph.D. thesis, University of Bradford, 1991).

[156] See section on 'Composition of "high" and "low" status glasses' above.

[157] Arbman, op. cit. in note 118, 142, Taf. 191:3.

[158] Ibid., 366, Taf. 192:1, right.

[159] Isings, op. cit. in note 50, 227, fig. 153:7.

[160] Arbman, op. cit. in note 52, 50.

[161] Ibid., 51, Abb. 6.

[162] Lundergårdh, op. cit. in note 46, 252–53.

[163] N. Lund, *Ottar og Wulfstan, to rejsebeskrivelser fra vikingetiden* (Roskilde, 1983).

[164] The official term Saami is used instead of the old term Lapp.

[165] Hougen, op. cit. in note 86.

[166] For a fuller discussion of radiocarbon dates from Borg, see O. S. Johansen, in *Borg, a North-Norwegian Chieftain's Farm from the Iron Age* (forthcoming).