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Seventh century or seventeenth century? Identifying glass beads from Scotland*

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ABSTRACT

This paper reconsiders glass beads that have hitherto been regarded as early medieval in date. Although several groups of these beads are known from important early Christian sites – St Ninian's Isle, Shetland, and Morham, East Lothian – a case is made here for a manufacture date between the 17th and 19th centuries AD *on the basis of typological parallels and surface analysis of the glass composition. Several of the groups of beads appear to have been found in graves and their significance in the context of early modern burial practice is explored. Here it is argued that, in the face of the sheer quantity of beads produced in post-medieval Europe, extreme care should be exercised when identifying glass beads, particularly when the objects in question have complex or uncertain archaeological contexts. Although surface analysis of glass composition has limitations, with careful interpretation it can nonetheless provide a quick, inexpensive and non-destructive means of narrowing the range of possible identifications. The type of glass can give a broad indication of date, and in some cases the detection of particular ingredients or quality of materials can indicate a more precise origin.*

INTRODUCTION

The study of glass beads in Scotland has a somewhat chequered past, and has on occasion lacked methodological rigour. Beads have often been left un-illustrated within site reports (eg Dunbar (Perry 2000)), regarded as culturally and chronologically undiagnostic (particularly monochrome blue glass beads) or (mis)identified on the basis of only very general visual similarity with better dated examples (such as a supposedly 'Anglo-Saxon' bead from Mouswald, discussed below). Recent study of the collections of National Museums Scotland (Blackwell in prep)[1] has made many new identifications of previously unidentified beads. This has been greatly aided by production of recent typologies (eg Guido 1999; Brugmann 2004; Mannion 2015) but it is mainly due to sustained attention being paid to this group of material for the first time.[2] This study indicated that there is a great potential for research among existing collections of beads from Scotland[3] and highlighted a number of mis-identifications which have been repeated in recent literature. One of these is addressed in more depth here.

The glass beads discussed in this paper comprise stray or poorly contextualised finds, but include groups from two important early Christian sites. The beads from one of these sites have in the past been identified as Anglo-Saxon, and this has formed the basis for subsequent dating of similar beads to the early medieval period. This paper will challenge this identification. Several types of beads and their archaeological contexts will be reviewed and alternative typological parallels and scientific analysis of the glass presented. The social and economic context of the beads will be explored and the implications for the identification and dating of beads in Scotland highlighted. It will be argued here that a post medieval/early modern origin should be actively

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ruled out, even for beads which appear to come from earlier archaeological sites or contexts, before other identifications are considered.

THE GLASS BEADS

The beads discussed below were all manufactured by winding glass around a circular-section rod. The starting point for this study was a distinctive type of bead with irregular and concave facets that occurs in various colours; examples from two sites and further stray or unprovenanced examples are discussed below. Other associated types from these sites are also discussed, and include 'black' and amber-coloured globular-shaped examples, irregular cylindrical beads in several colours, and a single polychrome bead, decorated with blue and white stripes.

With the exception of the St Ninian's Isle beads, most the Scottish examples discussed below are part of National Museums Scotlands' 'FJ' accession sequence. This is defined as 'beads, rings, etc of glass' and includes all examples that have not otherwise been categorised under a named site or general site-type code. In practice this means that they are virtually all stray or chance finds or from private collections, and those considered here were donated in the late 19th or early 20th centuries. This part of NMS' collections is therefore a particularly mixed bag, glass beads being far less easy to date or identify on visual examination alone than the comparable collections of metalwork gathered by the Museum of Antiquities at around the same time. In time, it will be necessary to thoroughly work through these beads, and those categorised separately from vast multi-period collections like Culbin Sands.

MORHAM, EAST LOTHIAN

Two groups of monochrome wound beads were found in the early 20th century in Morham churchyard. The record of the 'Donations to the Museum of Antiquities of Scotland' for 1927–8 includes a group of nine beads (illus 1), consisting of two 'black' globular examples and seven milky-white wound and irregularly faceted beads, referred to here as Morham Group 1 (Patullo 1927–8; NMS, accession number x.FJ 119). These were found while digging a grave on the east side of the church where it was believed that 'There had originally been a long stone-lined grave and at least another burial on the spot' (Patullo 1927–8). The second set of beads (here Morham Group 2), found several years later in 'the kirkyard of Morham' (Patullo 1933–4), consists of seven irregularly wound tubular beads in colourless glass (three), translucent ultramarine (three) and opaque mid-blue (one) (illus 2; NMS, x.FJ 127–33). Both sets of beads have been previously identified as Anglo-Saxon, and interpreted as having been found in long cists (Proudfoot & Aliaga-Kelly 1996: 5).[4] Part of an Anglo-Saxon cross-shaft was found at Morham and this is likely to have influenced identification of the beads. Proudfoot and Aliaga-Kelly, working before the publication of current Anglo-Saxon bead typologies, included both sets in their 1996 catalogue of the Anglo-Saxon small finds from Scotland on the basis that '… the shape but not the colours of these beads resemble examples from the [Anglo-Saxon] cemetery at Buckland, Dover' (Proudfoot & Aliaga-Kelly 1996: 5). The increase in publications concerning glass beads since then means it is possible now to reject this identification. Amongst Morham Group 1 are seven milky-white beads made from dichroic glass – these vary in colour under transmitted and reflected light, in this case blue-ish and yellow-ish. This is a distinctive glass, although it was not mentioned by Proudfoot and Aliaga-Kelly. The shape of this type of bead is also distinctive: these wound beads feature irregular and often concave facets. Beads with sharp, even and flat-sided facets are found among the Buckland assemblage and in Guido's Anglo-Saxon typology (classified by colour; see for example type 6iV, Guido 1999: pl 5) but they do not compare well to the shape of the Morham beads. Therefore, the colours, dichroic glass and form are not characteristics found among Anglo-Saxon beads.

ILLUS 1 Morham Group 1 beads. © Trustees of National Museums Scotland

ST NINIAN'S ISLE, SHETLAND

Excavation at the the chapel site of St Ninian's Isle – famous for the discovery in 1958 of a hoard of Pictish silver – recovered two groups of glass beads, among which are several examples similar to those from Morham. The St Ninian's Isle beads (illus 3) were not included in the 1973 excavation monograph (Small et al 1973) but have recently been assessed and published for the first time (Batey 2011: 65–70, illus 10 and 11). The two groups of St Ninian's Isle beads are markedly different in their make-up. Group 1 consists of multiple types of beads: 10 examples of wound blue glass, mostly barrel-shaped; a single example with irregular and concave facets of dark blue glass; a translucent annular of amber-coloured glass; two globular beads of an off-white glass; one annular bead of a similar glass; two irregular cylinders of dark blue glass; three 'black' globular beads; and a small, neat polychrome cylinder bead with a dark blue

ILLUS 2 Morham Group 2 beads. © Trustees of National Museums Scotland

body decorated with very fine, white, marvered stripes along its length which are covered by a colourless glass layer. Group 2 consists of eight globular beads of amber-coloured translucent glass, similar to that of the annular bead in Group 1.

The find circumstances of the beads are far from clear and several pieces of contradictory information have been discussed in the recent review of the site (Batey 2011: 65–7). A letter from one of the excavators, Alan Small, describes the archaeological context of the Group 2 beads as 'inside the nave'. Unfortunately, there is no depth given and from the structures which exist on the site they could belong to practically any period from the Iron Age upwards. Small noted that the Group 1 beads carried a label which said they were 'from grave c3, south-east of nave from the south-east angle' which, in his opinion, located them close to the 'so-called Founders Tomb' (Batey 2011: 65–6). A draft preliminary report of the excavations, preserved in Shetland Archives, presents a contradictory context for the beads: it lists finds from 1956 excavations within the nave as 'a late 17th-century copper coin wedged in the high altar, and brown and blue glass beads from post-Reformation interments' (Batey 2011: 66). However, Batey notes that Small subsequently refuted this post-Reformation attribution, confirming

to her that Group 1 had indeed been found in one of the 'long cists situated to the south of the apse of the medieval chapel' (Batey 2011: 67). Reassessment of the site demonstrated that there were at least two phases of long-cists, one in Phase III (early medieval), and one in Phase V, dated only to post mid-11th century. Almost all of the late and post-medieval burials were removed by the 1950s excavations. The chapel was abandoned in the 18th century, but burial continued at the site until the 19th century (Barrowman 2011: 207).

In choosing among these contradictory pieces of information, the recent reassessment of the beads suggested an early medieval long-cist burial, conceivably associated with the Pictish hoard, was the most likely find context for the beads. Although the dearth of well-dated parallels

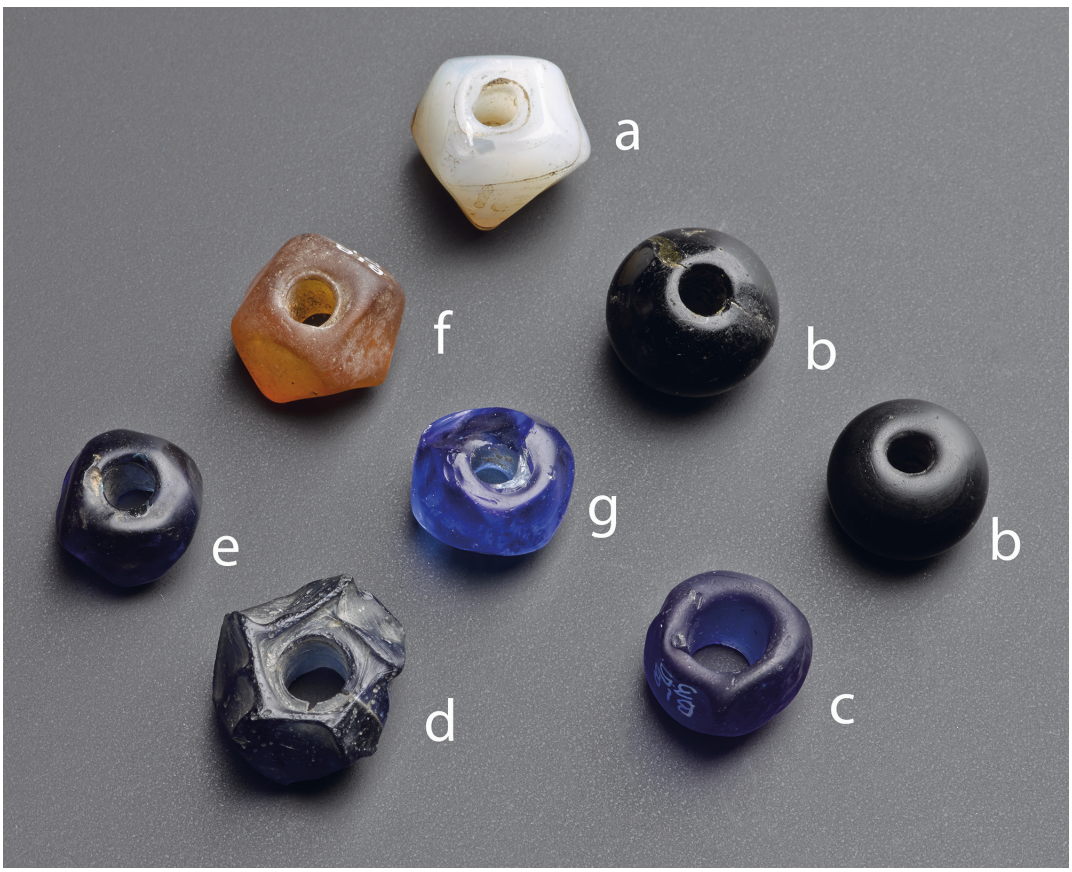
ILLUS 3 St Ninian's Isle beads. Group 2 consist of eight amber-coloured beads on the right of the image; the remainder are Group 1. © Trustees of National Museums Scotland

for the St Ninian's Isle beads was noted, an early medieval date was favoured (Batey 2011: 69). This discussion noted discovery of several sets of beads also apparently from long-cist graves: those from Morham, discussed above, and a set of (genuine) Anglo-Saxon beads from a grave at Hound Point, Dalmeny (NMS, x.EQ 340). The Morham beads provided both a typological parallel and an apparently similar long-cist context. General similarities between the amber-coloured beads and examples from Scottish Iron Age assemblages, and an unstratified parallel for one of the 'black' beads, were suggested, but no further close or well-dated parallels could be cited (Batey 2011: 67–9).

Limited preliminary scientific analysis of two of the beads, undertaken by Julian Henderson (referred to but not published in Batey 2011: 69), indicated 'an unusual composition'; one had arsenic present, '… highly unusual at such a potentially early date'. The implications of this were not explored further.

STRAY AND UNPROVENANCED BEADS

Among the beads in the National Museums Scotland's archaeology collections are a number of beads that provide good parallels for the irregularly faceted examples from Morham



ILLUS 4 Stray beads. Clockwise, from top, centre: (a) opalescent-white faceted bead, Cloister Seat; (b) two 'dark' globular beads, Cloister Seat; (c) blue faceted bead, Culbin Sands; (d) faceted navy blue, near Coulter; (e) faceted navy blue, unprovenanced (x.FJ 86); (f) faceted amber-coloured, Culbin Sands; (g) faceted bright mid-blue, Culbin Sands. © Trustees of National Museums Scotland

ILLUS 5 Three beads from Glenluce Sands. © Trustees of National Museums Scotland

Group 1 and St Ninian's Isle Group 1. From Cloister Seat, Aberdeenshire (NMS, x.FJ 43; illus 4a), is a particularly close parallel to the Morham beads – it is from a similar milky-white glass and has the same prominent winding marks. Also from Cloister Seat are two 'black' wound globular beads very similar to those from Morham Group 1 (illus 4b, NMS, x.FJ 40 and x.FJ 41). Stray finds of the faceted type are known from among the massive multi-period collections from Culbin Sands, Moray (illus 4c, 4f, 4g; NMS, x.BIB 35, x.BIB 36, x.BIB 51), and Glenluce Sands (illus 5 x.BHB 28, x.BHB 29, x.BHB 40): each of these two sites has produced two translucent blue and one translucent amber glass beads. A further deep translucent blue faceted bead from an unknown locality is also among the NMS bead collections (illus 4e; x.FJ 86) and a similar bead with more sharply defined facets is also known from the vicinity of Coulter, Lanarkshire (illus 4d; NMS x.FJ 30). In Perth Museum and Art Gallery are two further examples in translucent wine-coloured and amber-coloured glass (Hoffmann 2008); these are from the collections of J Roberts, an amateur field-walker active at the beginning of the 20th century in Moray (and particularly around the Culbin Sands area) and in the Scottish Borders around Melrose. Among four beads in NMS collections provenanced to Samhnan Insir on the Isle of Rum is another faceted bead in colourless glass (illus 6, bottom); all four are recorded within the Museum's catalogue as 18th or 19th century in date (NMS, h.1992.164.1–3 and h.1992.165). Among a group of six beads in NMS collections (illus 7; NMS, x.FJ 89), catalogued as 'Six beads of recent date bought together with FJ 82–8 in March 1900', are a further blue faceted bead, as well as a black globular and dichroic milky-white globular similar in shape (former) and glass (latter) to those from Morham. A further 55 beads of colourless glass (with a surface reminiscent of sea-worn glass) are similar in shape, though they lack the concave profile of facets and clear winding marks; purchased in 1920, they were said to have been 'found in a grave in the north of Scotland by a tinker woman' (illus 8; NMS continuation catalogue entry; x.FC

ILLUS 6 Four beads from the Isle of Rum, including a colourless-pale lilac faceted example, bottom centre. © Trustees of National Museums Scotland

111). From beyond Scotland, the collections of the British Museum's Department of Britain, Europe and Prehistory also contain a number of beads similar to those from Morham Group 1, including faceted beads in bright translucent blue, translucent amber, milky opaline and colourless glass (illus 9). These beads have only general Irish provenances and had been categorised as 'Celtic, 5th–11th centuries' (British Museum, 1892,0421.55, 32 beads from Ireland; and 1871,1210.80–4, 1871,1210.96–107, 1871,1210.112–113 from Northern Ireland). None are well-dated, all being stray finds or from old collections with poor provenance information. Amongst these poorly provenanced 'Celtic' beads are also a group beads identical to the polychrome striped bead from St Ninian's Isle (1892,0421.53, 12 beads from Ireland).

TYPOLOGICAL PARALLELS

Once the search for similar beads is widened beyond Scotland, and beyond archaeology collections, more closely datable parallels for the types of beads described above are not difficult to find. Beads of closely comparable shapes, often with similarly prominent wind marks, and in a similar range of colours can easily be found among known early modern beads. Glass beads were produced in vast quantities in Europe from around the 16th century but particularly in the 17th–19th centuries. Many were carried by explorers, missionaries and traders to non-European peoples around the world. These 'trade beads', as they are often called, were an important component in colonialisation and developing global trading systems (Sheer

Dublin 1987: 101), and were, for example, the European import most highly prized by Native Americans (Turgeon 2001–2: 87). Glass beads were also traded in Europe – for instance, French beads were exported to England as early as 1608 (Kidd 1979: 29) – but this has received less attention than their role in trade further afield (Dussubieux 2009). The most prolific European glass production centres were in Venice, Holland, Bohemia, Moravia and France; beads were also manufactured in smaller quantities in Germany, Spain, Belgium and England (Kidd 1979; Turgeon 2001–2). At the peak of production, the output of these centres was astounding: in 1764, Venetian glass workshops produced 44,000 pounds of glass beads a week (Kidd 1979: 19). It is estimated that Venetian glassworkers alone manufactured over a hundred thousand varieties of glass beads (Sheer Dublin 1987: 111).

These early modern beads vary from simple monochrome examples in a wide variety of shapes, to more complicated and distinctive polychrome beads. Some were manufactured by winding, others were drawn; wound beads could be made on a small scale and required less sophisticated equipment than drawn beads. Almost infinite variation is possible and therefore classifying wound beads is difficult (see Kidd & Kidd 1983, modified by Karklins 1983; 1985a for the most widely used classification system). Identifying where individual trade beads were produced is also problematic: glassworkers travelled across Europe, particularly from Venice, taking designs and techniques with them to centres elsewhere. Attempts at provenancing

ILLUS 7 'Six beads of recent date bought … in March 1900', NMS x.FJ 89. © Trustees of National Museums Scotland

ILLUS 8 Beads reportedly found in 'a grave in the north of Scotland', NMS x.FJ 111. © Trustees of National Museums Scotland

trade beads using scientific analysis are proving fruitful: for example, in distinguishing between assemblages of red beads from the 17th century found in various sites in America on the basis of levels of tin, copper and antimony, which may indicate a change from Dutch to possibly French manufacture (Sempowski et al 2001). However, with the sheer numbers of assemblages and types requiring study, this work is still only beginning to shed light on the complex kinds of networks represented by trade beads. It can also be very difficult to date trade beads closely as many designs continued to be made virtually unchanged for centuries. Again, there are indications of chronological changes in the composition of some colours of glass beads, for example, the use of different opacifiers in opaque white beads: tin rich (early to late 17th century), antimony rich (late 17th century to mid-19th century) and arsenic rich (very late 18th century to 20th century) (Hancock et al 1997; see Hancock 2013 for an overview of work on different colours and references therein); more work is required to establish whether these results can be extended beyond the assemblages analysed to date.

There is therefore a massive early modern European glass bead industry that produced a startling array of beads which ended up across the world after passing through multiple hands. Some beads from Scotland can easily be identified as early modern trade beads, such as a distinctive chevron-type bead from Mouswald in Dumfries and Galloway (illus 10; NMS, x.FJ 45). Lloyd Laing included this stray find in his catalogue of

ILLUS 9 One of the strings of beads provenance to Ireland in the collections of the British Museum. © Trustees of National Museums Scotland

Anglo-Saxon small finds from Scotland on the basis that it was 'not of a type found in Celtic areas … [and] similar beads come from several pagan Saxon graves' (Laing 1973: 45, no 2). This is, however, certainly of more recent manufacture: among European-made early modern trade beads 'perhaps no other bead has been as popular as the chevron', being produced from around 1500 by Venetian glassmakers, and from the 17th century by the Dutch (Sheer Dublin 1987: 117). 'For almost five hundred years, these [chevron] beads have been produced in the many millions and in several hundred varieties' (ibid). Other distinctive examples include a so-called 'raspberry' bead from Dryburgh, Scottish Borders (illus 11; NMS, x.FJ 143; Kidd & Kidd 1983: type Wiid, illus 4, pl 5, 225). Less distinctive beads can be more challenging to identify. Useful sources include bead sample cards from glass manufacturers or intermediary companies (eg Panini 2007: illus xxxiv), from excavations at early bead-making factories in Holland (eg Karklins 1983; 1985b; Baart 1988), and bead assemblages from North American sites where trade beads are plentiful and are the only or main type of bead found.

Parallels for the 'Morham type' wound beads with pressed facets formed while the glass was still viscid are readily identifiable, if not closely datable, among this body of evidence. Examples are described from excavations of various 16th–18th-century glasshouses and bead factories in Amsterdam in the following colours:

Illus 10 A chevron bead from Mouswald. © Trustees of National Museums Scotland

transparent light grey, transparent pale blue with a yellowish opaline cast, transparent amber, transparent ultramarine, transparent bright navy and transparent blue with a slight yellowish opaline cast (Karklins 1983: illus 2, left, row 4; Karklins 1974: 79–80, type W1b4; Baart 1988: 73). Though not illustrated, the description of the 'opaline' beads from Amsterdam appears to be a very good match for the dichroic glass from Morham. Other parallels for the dichroic milky glass also exist among trade beads, including one (tubular-shaped, not faceted) from a bead card, possibly dating to the early 20th century, that has been scientifically analysed (Davison et al 1971: 'Cambridge #1' in Table 1, discussed further below). Whilst dichroic glass was produced in antiquity and again from the early 17th century in Europe, its production was facilitated after 1880 when the Solvay process produced commercial soda with fewer chloride and sulphate impurities, which inhibit opalescence in glass (Davison et al 1971: 647). Other chronological indicators include a deep blue example of this faceted type excavated in Iceland from a context dated to 1780–1800 (Hreiðarsdóttir 2007; Elin Hreiðarsdóttir pers comm). Two faceted examples, one 'greenish-colourless', the other amber-coloured glass, were excavated from pits likely to date to the 18th century at Canute's Palace, Southampton (Platt 1975: 276, fig 249, no 1960–1), and another similar bead of 'clear pinkish-yellow', dated to the mid-18th to 19th century, was excavated from Winchester (Biddle & Creasey 1990: 664, no 2140). Two examples of similar beads have also been excavated from Scotland from contexts that support this early modern identification: half a faceted bead in near colourless glass from Linlithgow High Street (Hunter et al 2015: 35, cat 62); and a blue example from a post-medieval longhouse at Allt na Moine Buidhe in highland Perthshire (Cox 1999: 121, illus 8, no 21). As mentioned above, one of the faceted beads in NMS collections was described as 'recently made' in 1900.

The wound tubular beads from Morham Group 2 can also be closely paralleled among early modern beads, including among those collected by a private museum, the Picard Trade Bead Museum, in America, and excavated from Amsterdam (Karklins 1983: illus 2, left, rows 1–3).[5] Another distinctive type is represented amongst the Scottish beads by the polychrome striped example from St Ninian's Isle (and the British Museum's 'Celtic' beads): this is an early modern type, classified by Karklins as IIIb (1974: 74), and good parallels are published from excavations of early modern glass bead manufacturing sites in Amsterdam (Karklins

Illus 11 A raspberry bead from Dryburgh. © Trustees of National Museums Scotland

1985b: illus 4) and also as stray finds from the city (Karklins 1983: illus 2, right, row 8).

SCIENTIFIC ANALYSIS OF THE BEADS

Susanna Kirk

In order to confirm or reject an early modern identification for this collection of Scottish beads, analysis with non-destructive surface X-ray fluorescence (XRF) and scanning electron microscopy with compositional analysis (SEM-EDS) was undertaken on a selection of beads in NMS collections, the beads from St Ninian's Isle in Shetland Museum and Archive's collections, and two beads reported during the course of this research to the Treasure Trove Unit. The Appendix contains the methods and SEM-EDS data (Tables 1–5). The beads were analysed without any additional preparation and therefore may have been affected by glass weathering. The presence of high alkali content can be used an indicator that extensive weathering has not yet taken place (true for many of the beads analysed) as the ratio of silica to alkali is affected significantly by glass weathering processes. However, the data is discussed with an awareness that glass weathering may have affected the compositions produced. The St Ninian's Isle beads are referred to below by the published catalogue numbers (Batey 2011: 67–9; not all the beads from the site were available for analysis). The analytical results are grouped by colour below, and following this the interpretation of the results is presented.

ANALYTICAL RESULTS

All except three of the beads analysed were found to be either potash glass or lead glass. All the beads from Morham Group 2 (dark blue, mid-blue and colourless) are made from glass containing significant lead on XRF analysis. The colourless Morham Group 2 bead, which was also analysed by SEM-EDS in addition to XRF, has a low alkali content (predominately potash), almost no lime present and contains around 30% lead oxide. Other impurities, such as iron and manganese, are low, consistent with the use of refined raw materials. The Group 1 Morham beads, the Isle of Rum beads and all except two of the St Ninian's Isle beads were found to be made from potash fluxed glass. Variations in composition were noted between the different colours.

White opalescent beads

All of the white opalescent beads analysed (from Morham Group 1, St Ninian's Isle, Cloister Seat and the Treasure Trove example from Pitroddie) were found to contain significant phosphorous oxide, up to 8%, most likely from the use of calcium phosphate as an opalising agent and probably derived from bone ash as a fragment consistent with bone was found during SEM analysis of the Morham beads. Significant arsenic oxide (above 1%) was also found in one of the two opalescent beads from St Ninian's Isle (18).

Colourless beads

Arsenic was also found in the single colourless bead (h.1992.164.2) from the Isle of Rum, which is similar in general composition to the opalescent beads from Morham Group 1 and St Ninian's Isle but lacks any opalising agent. The colourless outer layer of the striped polychrome bead from St Ninian's Isle (15) was also analysed, but appears to have suffered significant weathering as its alkali levels are lower than would be expected; it was also unclear what contribution there was to the composition from the white and blue glass underneath. Both areas analysed on this bead did, however, suggest that its original alkali was soda (or mixed soda/potash) rather than potash, indicating a different composition to the other St Ninian's Isle beads.

Blue beads

Six blue beads from St Ninian's Isle (1, 9, 12, 17, 20 and 11) were analysed and five form a broad group of potash glasses which contain low levels of magnesia and high levels of phosphorous oxide (>5%). They are likely coloured by cobalt oxide, although it was not detected in beads 9 and 12. Cobalt is a very strong colorant in glass, with extremely low levels able to produce a strong blue colour. Bead 11 has a different composition

– with very low phosphorous oxide levels (<1%), higher magnesia (around 2% compared to <0.5% in the other five blue beads) and arsenic present above 1%. Another blue bead from the Isle of Rum (h.1992.165) was also found to be a potash fluxed glass coloured by cobalt oxide, although its alkali levels were lower than would be expected for a potash glass and its composition may been affected by weathering. A further bead from Rosemarkie (Highland), reported to the Treasure Trove Unit during the course of this research, was found to be a potash glass with very high phosphorus levels, suggesting the use of bone ash as an opalising agent.

Amber-coloured beads

Four amber beads from St Ninian's Isle (22, 23, 24 and 28) form a group of high alkali potash glasses with low magnesia levels (<0.5%), low phosphorous levels (<0.5%) and around 2–3% of aluminium oxide. No colorant oxides were found and it is likely the colour is caused by the iron/sulphur chromophore (the part of a molecule responsible for its colour), which requires very low levels of these oxides and a reducing atmosphere in the furnace to produce a range of amber and brown glasses (Weyl 1951). Bead 14 may also be a weathered example of the same group. An amber-coloured bead from the Isle of Rum (h.1992.164.1) has a similar composition to the St Ninian's Isle beads of the same colour.

Black beads

The two 'dark' glass beads from Morham Group 1 were also potash-lime-silica glasses but both contained significant levels of impurities, perhaps indicating that poorly refined raw materials were used in their manufacture. The black bead from the Isle of Rum (h.1992.164.3) was also a potash glass, containing significant iron (4%) but low alkali levels (around 13% potash); in this case it is unlikely to be due to weathering as this bead fragment was analysed on a broken edge. The two black 'glass' beads from St Ninian's Isle (19 and 16) have a very unusual composition with low silica levels (50%), very high aluminium oxide (>15%), high iron levels (*c* 10%) and high titanium levels (2–3%). It is possible that they may not actually be deliberately created glasses, but could instead be a vitreous silicate mineral or reused metallurgical slag.

Polychrome 'chevron bead'

SEM-EDS analysis of the layered chevron bead from Mouswald (x.FJ 45) found it to be very different in composition to the potash fluxed glasses discussed above. Each of the colours in the Mouswald bead was analysed individually but there may be some interaction between the layers. All four layers contain both soda and potash in varying amounts, suggesting a soda-rich (dark blue/blue/red) or mixed alkali (white) glass. All of the layers contain significant magnesia (2–4%), suggesting a plant ash alkali source. The dark blue glass forming the main bead is coloured by cobalt (0.7%) and also contains around 1% arsenic oxide, most probably from the cobalt ore. The pale blue glass layer has a similar overall composition but cobalt and arsenic were not detected, and its colour most likely derives from the low level of copper present (0.3%). The red layer also contains copper at a slightly higher level (0.5%), in addition to almost 4% iron oxide, and high levels of tin and lead (7%). The white layer has a different overall composition, consisting of a mixed alkali bulk glass and high levels of lead and tin creating the opaque white colour.

DISCUSSION OF ANALYTICAL RESULTS

The Group 2 Morham beads were found to be lead glass. Very high lead glass beads (with up to around 80% lead) are known from earlier periods (eg Robertshaw et al 2010) but colourless lead glass with potash as the primary alkali and refined raw materials is consistent with a late 17th or early 18th-century date. The colourless Morham Group 2 bead has lower alkali and higher silica than published leaded glass from this period (Dungworth & Cromwell 2006), but this probably indicates that a weathering layer depleted in alkali is present.

With the exception of the chevron bead, the remaining beads analysed were made from potash glass. Potash replaced soda as the main alkali (flux) in glass manufactured from the 8th century AD onwards (Wedepohl 1997), and

therefore the beads analysed here are later than this in date. The presence of calcium phosphate as an opalising agent in the opal beads indicates that they are most likely to be post medieval, bone ash being found only in Venetian glass in the medieval period (Verita 1990), and introduced more widely from the 17th century. A dichroic bead, probably made during the early 20th century, analysed by Davison et al, differed from the opalescent beads analysed here in being leaded glass, but is also likely to have featured bone ash as the opalising agent, perhaps in combination with arsenic in this case (Davison et al 1971: 651, 655). The low level of magnesia (0.5%) in the Morham opalescent beads suggests the use of purified raw materials; medieval and early post-medieval glasses from England contain around 3–8% magnesia (Brill 1999: 250). Refined potash may have been used to change the refractive properties of the glass: its use to imitate the refraction of lead crystal has been noted in Belgian glasses from the early 18th century, and these too contain very little magnesia (Van der Linden et al 2005).

The presence of arsenic in several of the opalescent and colourless beads also supports a post-medieval date. Arsenic is common in beads coloured with cobalt from several eras as it is frequently found in cobalt ores (Gratuze et al 1992). However, in other colours of glass the use of arsenic as a fining agent in glassmaking is attested to from the early 19th century (Cable 2008). Close parallels to the opalescent beads were also found in some 19th-century African glass trade beads from the NMS collection (unpublished NMS report, AR201141), which contained very similar levels of phosphorous and magnesia to the opal beads from Morham and St Ninian's Isle, although with higher arsenic.

The composition of each of the various glasses that make up the polychrome chevron bead from Mouswald indicate that it is highly likely to date from the 17th century. Lead-tin white was the primary opacifier for white glass trade beads of the 17th century (Hancock et al 1997) and red glass trade beads coloured with copper and opacified with tin are found from a similar period (Sempowski et al 2001). Arsenic-rich cobalt ore is also consistent with a 17th-century date (Gratuze et al 1992; Hancock et al 2000).

DISCUSSION

Scientific analysis supports typological parallels indicating a 17th–19th-century date for all of the beads discussed above. While the study of early modern trade beads found at Native American sites is a major field of study, there has been far less attention given to production and circulation of these same beads in Europe (Dussubieux 2009; Baart 1988: 67). In contrast to the extensive documentary (and in some cases excavated) evidence for post-medieval bead production on the continent (Dussubieux 2009; Baart 1988; Karklins 1983; Karklins 1985b; Turgeon 2001–2), there is currently very little evidence of comparable manufacture in Scotland and from Britain more generally, although the discovery of a 17th-century bead-making site in Hammersmith, London, demonstrates it did occur (Egan 2008). One instance of 'beidmaker' given as an occupation within parish records dating to 1636 hints at a possible sideline for early glasshouses in Scotland; the person in question was a man working with Italian glassmakers employed in Scotland (Turnbull 2001: 56).

Vast quantities of beads were made in Holland and elsewhere on the continent, and some were shipped across for British markets. For example, beads are amongst glass wares listed in the 1612 'Book of Rates of Customs and Valuation of Merchandises in Scotland' and thus were theoretically available (Turnbull 2001: 25). There is growing material culture evidence for established trade links between the Low Countries and Scotland from the 17th century, in the form of relatively cheap metal objects, such as women's hair pins, thimbles, weight sets and knives, reported as Treasure Trove (Stuart Campbell pers comm). Imported glass vessels from the 16th–17th centuries, including a sherd from a likely example from the Low Countries, from Bayanne, Shetland (Murdoch & Romankiewicz 2013), and 16th- to 18th-century small continental copper coins turn up in Scottish contexts particularly near fishing

communities with German, Dutch, and other continental traders, for example, a schilling of Schleswig-Holstein of 1712, from the Sands of Breckon, Yell, Shetland (identified by Caldwell in Carter & Fraser 1996: 287). It may be that glass beads formed a part of this trade across the North Sea. Shetland in particular has a complex history of late and post-medieval trading with the Hanseatic League and latterly Dutch, English and Scottish traders. Both St Ninian's Isle and Bigton (immediately opposite on Mainland Shetland) have been identified as trading sites in the 17th century (Smith 1984: 13–14; Mehler & Gardiner 2013: 8). Other material from the recent re-excavation at St Ninian's Isle might support this. A small assemblage of 16th/17th-century pottery was recovered, which highlights trading links with Europe (Will 2011: 73–4), and a late 17th-century coin and worn Limoges enamel cross fragments, found pushed into the fabric of the altar, may be votive offerings by visitors to the Isle at that time (Barrowman 2011: 205–6).

From the 9th to 15th centuries, beads were not commonly worn as necklaces; this changed over the following centuries, but not until the 19th century were beads a common item of affordable jewellery in England (Biddle & Creasey 1990: 660). Semi-precious stones were sometimes made into beads, for example, an almandine garnet bead excavated from a Georgian house, Temple End, High Wycombe, Buckinghamshire (Lucas & Regan 2003: 185, 200, no 42), and the faceted beads discussed above may be imitating semi-precious stone beads, perhaps agate in the case of the dichroic examples from Morham. Beads (particularly very small, so-called 'seed beads') might alternatively be sewn onto clothes, or function as buttons, and a fascinating survival from Northamptonshire of a 16th–17th-century silk face mask hints at other, occasional uses for beads: worn to shield gentlewomen from the sun, these masks were held in place by a bead on a string that was gripped between the wearer's teeth (Lewis 2012: 212–13), in this case a black globular bead, visually similar to those from Morham.

As discussed above, accounts of their discovery suggest the possibility that beads from both Morham and St Ninian's Isle were included in graves. The description of a 'stone-lined grave' at Morham was accepted by archaeologists as referring to an early medieval long-cist (Proudfoot & Aliaga-Kelly 1996: 5). However, there was significant variation among early modern burial practices prior to coffin burial becoming the norm (for those that could afford it) and it is possible that the minister of Morham Kirk was describing a stone-lined grave from the post-Reformation period. Early modern burial usually involved the corpse being dressed (either in 'false' clothes made for the grave, or in clothes worn during life) and then wound in a winding sheet or shroud, fastened by a small pin. Dress objects or other personal items were sometimes included in the grave, for instance, mourning or wedding rings found among burials excavated at Christ Church, Spitalfields (Cox 1996: 116–17).

The few examples of beads excavated from post-medieval graves have, however, tended to be interpreted as rosaries, rather than jewellery. By the 13th century, wearing of rosaries had become fashionable, including those formed from glass beads (Biddle & Creasey 1990: 660). Rosaries are rare finds in post-Reformation period graves, but several examples have been identified from burials among the minority Catholic population in London, and from Catholic Ireland (Tarlow 2011: 44–5). For instance, glass beads of 17th–19th-century date were found associated with a copper alloy crucifix in the grave of a young adult male at the burial ground of New Bunhill Field, London (Miles with Connell 2012: 48, illus 51), and three burials in a 19th-century workhouse cemetery in Ireland included rosary beads (Rogers et al 2006: 96, illus 4). Religious grave-goods like rosaries are one of the only ways of distinguishing between Protestant and Catholic burials of this period: although both the liturgy relating to burial and the relationship between the living and the dead were fundamentally different, the burials are very similar in terms of material remains. Pockets of Catholicism survived the Reformation in Scotland; there is some evidence for the continued limited use of the rosary in Scotland beyond the Reformation (McRoberts 1972), and burial was very slow to be reformed (Gordon Raeburn pers comm),

so internment with a rosary remains a possible interpretation. Neither of the groups of beads from Morham are numerous enough to represent even an abbreviated 'single decade' form of rosary (which might typically feature 10 beads with a larger bead or crucifix), though it is possible that not all were recovered by the gravediggers, or that knots or wooden beads made up the string to an appropriate quantity. There is, in any case, considerable variation among the quantities of beads that made up later medieval and early modern rosaries (Biddle & Creasey 1990: 660); burials, probably from the 19th century, at Manorhampton Workhouse, Co Leitrim, included rosaries composed of as few as eight beads (together with a metal crucifix and heart-shaped plaque) (Rogers et al 2006: 96).

Alternatively, inclusion of beads (apparently lacking an associated crucifix) in early modern burials might be the result of folk-beliefs (David Forsyth pers comm). Belief in curing and protecting amulets and charms was very persistent in post-medieval Scotland, and a diverse range of objects were believed to have amuletic properties: for instance, rock crystal balls, amber beads, natural 'found' objects, such as fossils or exotic seed-pods, and recovered prehistoric objects such as axeheads (Cheape 2008). These could also include glass beads: a letter written in 1699 by Edward Lhwyd (Keeper of Antiquities at the Ashmolean Museum, Oxford), concerning the use of amulets in Scotland, observed that a hollow cylinder of blue glass, known as the 'Snail-stone', was prized for its ability to cure sore eyes (Britten 1881: 167).

The attribution of beads from both Morham and St Ninian's Isle to graves may in fact be erroneous; neither are from well excavated and documented contexts. However, the use of church sites more generally for the votive deposition of objects in the post-medieval period is attested.[6] For example, R B K Stevenson highlighted the many un-worn 17th- and 18th-century coins that appear to have been deposited singly (rather than as a hoard) at the Orkney chapel site of Deerness (Stevenson 1986: 343). As mentioned above, the chapel at St Ninian's Isle produced a 17th-century coin from within the body of the altar. Stevenson compared this practice to the leaving of votive gifts at holy wells, and cited as a parallel a well at Kenmore, Perthshire, that had produced post-medieval coins, pins and, interestingly, an opalescent bead (Gillies 1925: 77); unfortunately the bead is lost and so cannot be compared with those from Morham.

Even after chapel sites ceased to be used by the church, burial by members of the local community could continue. St Ninian's Isle chapel was demolished in 1774, but burial continued to around 1840. After burial ceased, church sites would still be visited and, in many cases, remain close to domestic settlement: at Morham, small-scale excavation at the adjacent manse recovered 16th–18th-century pottery, bottle glass and clay pipes, some of which may have been continental imports (Moore & Richardson 2008); it is possible that the beads, too, relate to habitation of the manse.

Whilst longevity of use and deposition might be expected at church sites, it must also be borne in mind when interpreting beads from other kinds of archaeological sites. The broch site of Dun Beag, Skye, was excavated between 1914 and 1920 (Callander 1921) and produced a wealth of finds that were, inevitably, not recorded to modern standards. Several hundred beads were recovered during the excavations, and include several with good archaeological parallels, such as a blue barrel-shaped bead with marvered white criss-cross trails (NMS, x.GA 1104) that is closely paralleled by an example from Dunadd (Lane & Campbell 2000: 176, pl 24, cat 1593); both are examples of an early medieval Irish type (Mannion 2015). There is also a faceted bead, but scientific analysis has identified this as rock crystal rather than glass and so it can be excluded from the group of Morham-type faceted beads. Six beads from Dun Beag (NMS, x.GA 1106–x. GA 1111) do not find close parallel among beads from similar sites; among these are two globular beads, one in 'black' glass (similar to Morham). There have been some recent attempts to reassess some of the small finds from Dun Beag: a re-analysis of the pottery for instance suggested the possibility that some medieval pottery could be among the site's assemblage (MacSween 2002: 149), and coins dating from 12th–18th centuries attest to re-use or re-visiting of the site over the

medieval and post-medieval periods (Callander 1921: 128). The report of the excavation made in 1921 had this to say about the glass beads:

> A rather disconcerting discovery was made in the form of several hundred globular glass beads of various shades of blue, amber, red, green, transparent and opaque white colour, also some oval opaque yellow beads … These ornaments were not in the least decayed on the outside and though many of them were of very crude manufacture, with irregularly shaped holes and occasionally showing two stuck together, they cannot be considered prehistoric relics. They were all found close to the base of the wall … which led to the suggestion that they might have been lost by girls playing about the dun, and have trickled down the interstices between the stones … (Callander 1921: 130–1).

CONCLUSION

Several of the groups of beads discussed here came from 'suggestive' archaeological contexts: from the vicinity of a hoard of Pictish silver, and from what had been interpreted as a long-cist burial, both at sites of early Christian churches. However, these associations are not sufficient alone to justify an early date for the beads in question. Casting the net wider in the search for parallels, combined with speculative non-destructive scientific analysis, provides a more rigorous approach. Surface analysis through SEM and XRF has limitations, but in some cases can give a broad indication of the date of manufacture – and the presence of particular ingredients in the glass composition can provide finer chronological information. Crucially, the sheer number of glass beads produced in the early modern era means that this identification should be actively ruled out before parallels are sought amongst archaeological typologies. The longevity of use attested by sites like St Ninian's Isle should be anticipated when planning and interpreting future fieldwork and post-excavation analysis.

Whether the beads discussed here had been included within graves or subject to a different kind of deposition at a church site remains unclear, but either scenario raises interesting questions about the uses and meanings attached to beads in the post-medieval period. Their provenance, frustratingly, also remains uncertain. While there has been much attention given to post-medieval trade beads recovered in North America, their circulation within Europe remains distinctly understudied. These beads may be part of a growing body of inexpensive items recognised from Scotland that resulted from increasing trade across the North Sea. But the role Britain played in the manufacture of these mass-produced beads remains very uncertain, and a more local provenance remains, on the basis of present evidence, a possibility.

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END NOTES

1 This involved systematic examination of all NMS x.FJ accession numbers (the general glass beads classification) and some but not all beads from excavation assemblages that include early medieval material.
2 Lack of specialist attention to beads is not a problem limited to Scotland; Hreiðarsdóttir (2007) also makes a similar point for study in Iceland.
3 This potential is also demonstrated by Hoffmann's (2008) study of beads in the collection of Perth Museum and Art gallery.
4 Here, the second group are wrongly described as drawn when all are clearly wound, and the faceted beads are misleadingly described as 'biconical' and 'white'. The beads feature in the permanent galleries at National Museums Scotland and the displays follow Proudfoot and Aliaga-Kelly's identification.
5 The Picard Trade Bead Museum's online resources provides a wealth of colour images of trade beads in one place, useful given the vast numbers of types and lack of typology or publications with sufficient numbers of images

to aid identification. Examples comparable to those from Morham: http://www.picardbeads.com/trade_beads/c_77f.html.

6 Other material associated with Morham Kirk in NMS collections includes three charm stones of very doubtful authenticity (NMS h.NO 105); Hugh Cheape pers comm.

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Appendix

ANAYSIS OF GLASS BEADS

Susanna Kirk

Analysis of the beads was undertaken using XRF (Morham) and SEM-EDS (Morham, Mouswald, St Ninian's Isle, Isle of Rum, Treasure Trove beads) (National Museums Scotland unpublished reports AR2011/53 and AR2011/63). The semi-quantitative SEM-EDS results are presented in Tables 1–5 and the XRF results discussed briefly below. Analysis was carried out on uncleaned surfaces and so may have been affected by weathering, which would reduce alkali levels and increase silica levels at the glass surface. Further work would be required to ascertain the exact composition of these glasses.

X-RAY FLUORESCENCE METHOD

The XRF system used was an Oxford Instruments ED 2000 with Oxford Instruments software ED 2000SW version 1.31. The analysed area was irradiated with a primary X-ray beam produced by a Rhodium target X-ray tube. The primary beam was collimated to give an analysed area of about 4mm × 2mm. Secondary X-rays were detected with a silicon (lithium) solid state detector. The detection limit varies depending on the elements, matrix and analytical conditions, but is typically in the range of 0.05%–0.2%. As the analytical technique has a limited penetration depth, the reported compositions may not be representative of the bulk of the object if there is a chemically distinct surface layer. Spectra were collected under the conditions 'Old XRF'. This uses an operating voltage of 46kV and a current of up to 1000μA (set automatically for a 45% dead time) without a primary beam filter to ensure detection of all elements of atomic number 19 or above.

SCANNING ELECTRON MICROSCOPY SEM-EDS METHOD

The sample was placed directly onto a holder on the stage and examined using the CamScan MX2500 SEM in controlled pressure (Envac) mode. Elemental analysis was provided using a Noran Vantage EDS system and using Vista software.

The specific conditions were:

- 20kV accelerating voltage
- ×10 to ×500 magnification
- 4 quadrant fluorescence back scatter electron detector (BSC)
- 5 spot size
- Fully open lower apertur.
- 10Pa chamber pressure
- Si(Li) energy dispersive X-ray analysis (EDS)
- 120s counting time for EDS

Selected areas were analysed using the EDS system at various magnifications, all using the spot mode. Various spectral images, spectra and images were recorded. Semi-quantitative data was checked against glass standards 76C144, 148 and 150 (Morham Kirk) and Corning glass standards A and B for all other samples, with good agreement found for the major and minor oxides. Detection limits were ~0.1% for the X-ray microanalysis, depending on the element; CoO was found to have a detection limit of 0.04% as the equipment was able to detect this level consistently in Corning Standard B. This study was not looking at trace elements and another, more sensitive, technique would be required for this. Tables 1–3 present the SEM-EDS data for the beads analysed.

XRF RESULTS

The XRF results (spectra in AR2011/53, NMS unpublished report) showed that the Morham Group 1 faceted beads (x.FJ 119) contained significant potassium and calcium, with traces of iron, manganese, rubidium and strontium; no colorants were identified. The Morham Group 1 black beads appeared to be of similar composition but contained significant manganese and iron, possibly elements creating the colour (see also Table 1 for SEM-EDS results). The blue, turquoise and colourless glass beads from Morham Group 2 were found to contain significant lead, suggesting that they were lead glasses. The blue glass was most probably coloured with cobalt, and the turquoise with copper.

TABLE 1
Morham glass beads: SEM-EDS analysis (oxide wt%)

Acc No (colour)	*SiO_2*	*Al_2O_3*	*CaO*	*MgO*	*Na_2O*	*K_2O*	*Fe_2O_3*	*TiO_2*	*CoO*	*CuO*	*MnO*	*NiO*
X.FJ 119 (opalescent, faceted)	58.6	0.9	13.6	0.5	0.7	17.2	0.4	0.1	<0.04	<0.1	0.2	<0.1
X.FJ 119 (black)	60.8	3.1	16.4	1.9	1.2	10.8	1.3	0.2	<0.04	0.1	0.6	0.1
X.FJ 119 (black)	59.5	6.4	11.9	2.2	1.1	12.7	3.6	0.3	<0.04	<0.1	0.3	<0.1
X.FJ 127 (colourless)	61.2	1.0	0.1	0.1	1.7	5.6	0.2	<0.1	<0.04	<0.1	<0.1	<0.1

TABLE 1 *(continued)*

Acc No (colour)	*ZnO*	*As_2O_3*	*SnO_2*	*Sb_2O_3*	*BaO*	*PbO*	*Cr_2O_3*	*P_2O_5*	*SO_3*	*Cl*	*SrO*
X.FJ 119 (opalescent, faceted)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	6.3	0.6	0.1	0.6
X.FJ 119 (black)	0.1	<0.1	<0.1	<0.1	0.2	0.1	0.1	2.1	0.7	0.1	0.2
X.FJ 119 (black)	0.1	0.2	<0.1	<0.1	0.1	0.1	0.1	0.6	0.7	0.1	0.1
X.FJ 127 (colourless)	0.1	<0.1	0.2	<0.1	0.1	27.7	<0.1	0.4	<0.1	0.4	1.2

TABLE 2
Isle of Rum and Treasure Trove beads: SEM-EDS analysis (oxide wt%)

Acc No (colour)	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	TiO_2	CoO	CuO	MnO	NiO
H.1992.164.1 (yellow)	65.3	1.9	11.8	0.9	1.1	17.0	0.2	0.1	<0.04	<0.1	0.1	<0.1
H.1992.164.2 (colourless, faceted)	62.7	1.3	10.4	2.5	0.4	14.1	0.4	<0.1	<0.04	<0.1	0.3	<0.1
H.1992.164.3 (black)	63.5	2.3	9.7	0.9	2.5	13.3	4.0	0.1	<0.04	<0.1	0.5	0.1
H.1992.165 (blue)	73.7	0.9	6.3	0.5	2.6	13.4	1.3	<0.1	0.10	0.1	<0.1	<0.1
TT Pitroddie (opalescent white)	62.2	1.9	11.5	0.7	1.0	14.6	1.3	0.1	<0.04	0.2	<0.1	<0.1
TT Rosemarkie (blue)	68.7	1.5	8.6	0.7	1.5	10.5	0.9	0.3	<0.04	<0.1	0.1	<0.1

TABLE 2 *(continued)*

Acc No (colour)	ZnO	As_2O_3	SnO_2	Sb_2O_3	BaO	PbO	Cr_2O_3	P_2O_5	SO_3	Cl	SrO	ZrO_2
H.1992.164.1 (yellow)	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.4	0.7	0.2	<0.1	<0.1
H.1992.164.2 (colourless, faceted)	<0.1	1.2	<0.1	<0.1	<0.1	<0.1	0.1	0.3	0.8	0.2	<0.1	<0.1
H.1992.164.3 (black)	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	2.3	0.3	0.3	<0.1	0.1
H.1992.165 (blue)	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.1	0.2	<0.1	<0.1
TT Pitroddie (opalescent white)	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	5.0	0.7	0.5	<0.1	0.2
TT Rosemarkie (blue)	<0.1	0.2	<0.1	0.1	0.1	0.1	<0.1	5.8	0.3	0.5	<0.1	<0.1

TABLE 3
Mouswald 'chevron bead', x.FJ 45: SEM-EDS analysis (oxide wt%)

Acc No (colour)	*SiO_2*	*Al_2O_3*	*CaO*	*MgO*	*Na_2O*	*K_2O*	*Fe_2O^3*	*TiO_2*	*CoO*	*CuO*	*MnO*	*NiO*
x.FJ 45 (dark blue)	60.6	3.3	7.6	4.4	11.3	3.8	1.6	0.1	0.7	0.2	0.4	0.1
x.FJ 45 (pale blue)	59.7	3.9	8.2	3.7	11.0	3.9	2.7	0.1	<0.04	0.3	0.3	<0.1
x.FJ 45 (white)	45.1	2.6	5.6	2.3	7.9	11.2	1.5	0.1	0.1	0.2	0.6	0.2
x.FJ 45 (red)	51.9	3.2	5.8	3.4	10.7	3.6	3.6	0.1	0.2	0.5	0.3	<0.1

TABLE 3 *(continued)*

Acc No (colour)	*ZnO*	*As_2O_3*	*SnO_2*	*Sb_2O_3*	*BaO*	*PbO*	*Cr_2O_3*	*P_2O_3*	*SO_3*	*Cl*	*SrO*	*ZrO_2*
x.FJ 45 (dark blue)	0.1	1.1	1.0	0.2	0.1	1.7	<0.1	0.6	0.5	1.0	<0.1	<0.1
x.FJ 45 (pale blue)	0.2	<0.1	1.0	<0.1	0.3	1.5	<0.1	0.6	1.4	1.2	<0.1	<0.1
x.FJ 45 (white)	0.1	<0.1	12.1	0.2	0.2	12.7	<0.1	0.4	1.2	1.1	0.1	0.1
x.FJ 45 (red)	0.4	0.3	6.9	0.4	<0.1	6.9	<0.1	0.5	0.5	0.7	0.2	<0.1

TABLE 4
Cloister Seat beads: SEM-EDS analysis (oxide wt%)

Acc No (colour)	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	TiO_2	CoO	CuO	MnO	NiO
x.FJ 43 (opalescent white)	58.7	2.0	11.9	1.2	1.3	14.0	0.3	< 0.1	0.05	0.21	<0.1	0.1
x.FJ 40 ('black')	46.8	16.7	8.4	5.4	3.1	2.4	11.8	2.6	<0.04	0.09	0.31	0.1
x.FJ 41 ('black')	53.3	7.9	15.5	4.4	1.4	8.6	3.9	0.3	<0.04	<0.1	0.43	<0.1

TABLE 4 *(continued)*

Acc No (colour)	ZnO	As_2O_3	SnO_2	Sb_2O_3	BaO	PbO	Cr_2O_3	P_2O_5	SO_3	Cl	SrO	ZrO_2
x.FJ 43 (opalescent white)	0.2	0.9	0.1	<0.1	0.2	0.2	<0.1	7.9	0.6	0.4	<0.1	<0.1
x.FJ 40 ('black')	0.1	<0.1	0.2	<0.1	0.2	0.2	0.1	0.7	0.6	0.1	<0.1	<0.1
x.FJ 41 ('black')	<0.1	0.1	0.1	0.6	0.5	0.6	0.1	1.3	0.8	0.2	<0.1	<0.1

TABLE 5
St Ninian's Isle beads: SEM-EDS analysis (oxide wt%)

Cat No (colour)	*SiO_2*	*Al_2O_3*	*CaO*	*MgO*	*Na_2O*	*K_2O*	*Fe_2O_3*	*TiO_2*	*CoO*	*CuO*	*MnO*	*NiO*
14 (yellow)	74.3	3.9	7.1	0.7	0.9	11.4	0.3	<0.1	<0.04	0.1	0.1	0.1
2 (opalescent white)	60.7	1.0	10.8	1.0	0.5	16.3	0.2	0.1	0.10	<0.1	<0.1	<0.1
18 (opalescent white)	59.4	1.0	10.3	2.0	0.9	15.9	0.1	<0.1	<0.07	<0.1	<0.1	<0.1
15.1 (striped)	72.6	8.1	5.3	0.8	4.7	3.2	0.7	<0.1	<0.04	<0.1	0.2	0.1
15.2 (striped)	71.4	3.3	7.0	1.5	8.8	4.2	0.6	0.1	<0.04	<0.1	0.2	<0.1
11 (blue)	69.4	1.4	9.1	1.7	1.1	14.5	0.2	<0.1	0.05	<0.1	<0.1	0.1
20 (dark blue)	64.2	2.1	9.7	0.6	0.6	15.0	0.4	<0.1	0.06	<0.1	<0.1	<0.1
17 (blue)	60.5	1.5	10.8	0.5	0.9	15.2	0.4	0.1	0.04	<0.1	<0.1	<0.1
12 (blue)	59.1	0.9	11.8	0.5	0.5	17.5	0.3	<0.1	<0.04	<0.1	<0.1	<0.1
9 (blue)	61.5	1.1	10.7	0.3	0.6	15.8	0.3	<0.1	<0.04	<0.1	0.1	<0.1
1 (blue)	59.9	1.0	11.9	0.3	0.7	16.9	0.3	<0.1	0.11	<0.1	<0.1	<0.1
24 (amber-coloured)	65.1	1.1	12.3	0.2	0.6	19.8	0.1	<0.1	<0.04	<0.1	<0.1	<0.1
22 (amber-coloured)	69.1	2.0	10.7	0.3	0.8	16.1	0.1	<0.1	<0.04	0.1	<0.1	<0.1
28 (amber-coloured)	70.2	1.2	10.7	0.3	0.9	15.4	0.1	<0.1	<0.04	<0.1	<0.1	<0.1
23 (amber-coloured)	69.1	1.3	11.0	0.2	0.9	16.6	0.1	<0.1	<0.04	<0.1	<0.1	<0.1
25.1 (amber-coloured)	69.3	0.7	11.1	0.2	0.8	16.8	0.1	0.1	<0.04	<0.1	0.1	<0.1
25.2 (amber-coloured)	69.8	2.2	10.5	0.1	1.0	15.2	<0.1	0.1	<0.04	<0.1	0.1	<0.1
19 (black)	51.3	16.6	7.0	6.9	3.9	1.1	9.4	2.0	0.04	0.1	0.2	<0.1
16 (black)	48.7	14.5	9.3	5.6	2.7	1.3	14.2	2.9	0.05	0.1	0.3	0.1

TABLE 5 (*continued*)
St Ninian's Isle beads: SEM-EDS analysis (oxide wt%)

Cat No (colour)	*ZnO*	*As_2O_3*	*SnO_2*	*Sb_2O_3*	*BaO*	*PbO*	*Cr_2O_3*	*P_2O_5*	*SO_3*	*Cl*	*SrO*	*ZrO_2*
14 (yellow)	0.2	0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	0.3	0.2	0.2	< 0.1	< 0.1
2 (opalescent white)	< 0.1	0.1	< 0.1	0.1	0.1	< 0.1	0.1	8.0	0.7	0.1	< 0.1	0.3
18 (opalescent white)	< 0.1	1.8	< 0.1	< 0.1	0.1	< 0.1	< 0.1	7.7	0.8	0.1	< 0.1	< 0.1
15.1 (striped)	0.5	0.3	< 0.1	0.6	0.3	< 0.1	< 0.1	0.8	1.0	0.8	< 0.1	< 0.1
15.2 (striped)	< 0.1	< 0.1	< 0.1	0.5	< 0.1	< 0.1	< 0.1	0.9	0.5	1.0	< 0.1	< 0.1
11 (blue)	< 0.1	1.2	< 0.1	< 0.1	0.1	< 0.1	0.1	0.3	0.5	0.2	< 0.1	< 0.1
20 (dark blue)	0.1	< 0.1	< 0.1	0.2	0.1	< 0.1	< 0.1	6.0	0.3	0.1	0.2	0.2
17 (blue)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	8.3	1.1	0.2	0.1	0.4
12 (blue)	0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	8.1	0.9	0.1	< 0.1	< 0.1
9 (blue)	< 0.1	0.2	< 0.1	0.2	0.1	< 0.1	0.1	8.1	0.7	0.1	< 0.1	< 0.1
1 (blue)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	7.7	0.8	0.1	< 0.1	< 0.1
24 (amber-coloured)	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.2	0.2	<0.1	<0.1
22 (amber-coloured)	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.2	0.3	0.2	<0.1	<0.1
28 (amber-coloured)	<0.1	<0.1	<0.1	0.7	<0.1	<0.1	<0.1	0.1	0.2	0.2	<0.1	<0.1
23 (amber-coloured)	<0.1	0.2	<0.1	<0.1	0.1	<0.1	<0.1	0.3	0.1	0.2	<0.1	<0.1
25.1 (amber-coloured)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.3	<0.1	0.2	<0.1	<0.1
25.2 (amber-coloured)	<0.1	<0.1	<0.1	0.4	0.1	<0.1	<0.1	0.3	0.1	0.2	<0.1	<0.1
19 (black)	<0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	1.0	0.1	<0.1	<0.1	<0.1
16 (black)	0.1	0.3	0.1	0.5	<0.1	<0.1	<0.1	0.9	0.2	0.1	<0.1	0.1