

# SHAW HOUSE, NEWBURY, BERKSHIRE AN INVESTIGATION OF THE WINDOW GLASS

## TECHNOLOGY REPORT

David Dungworth and Amanda Loaring



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## **SUMMARY**

Refurbishment of Shaw House, Newbury provided the opportunity to analyse a range of window glass. Over a hundred samples of window glass were collected, including samples from a window constructed at the end of the 17th century and blocked c1728 (Room B6) as well as windows installed between c1690 and c1720. The analysed window glass includes three major glass types: high-lime low-alkali, mixed alkali and soda-lime. The *in situ* samples from the turn of the 18th century demonstrate that the use of high-lime low-alkali glass was superseded by mixed alkali glass c1700. This mixed alkali glass was made using seaweed ash (kelp) as a flux and enabled the production of less strongly coloured window panes. The results of the analysis of the Shaw House window glass contributes to an on-going research programme into the manufacture of window glass from c1500 to c1950.

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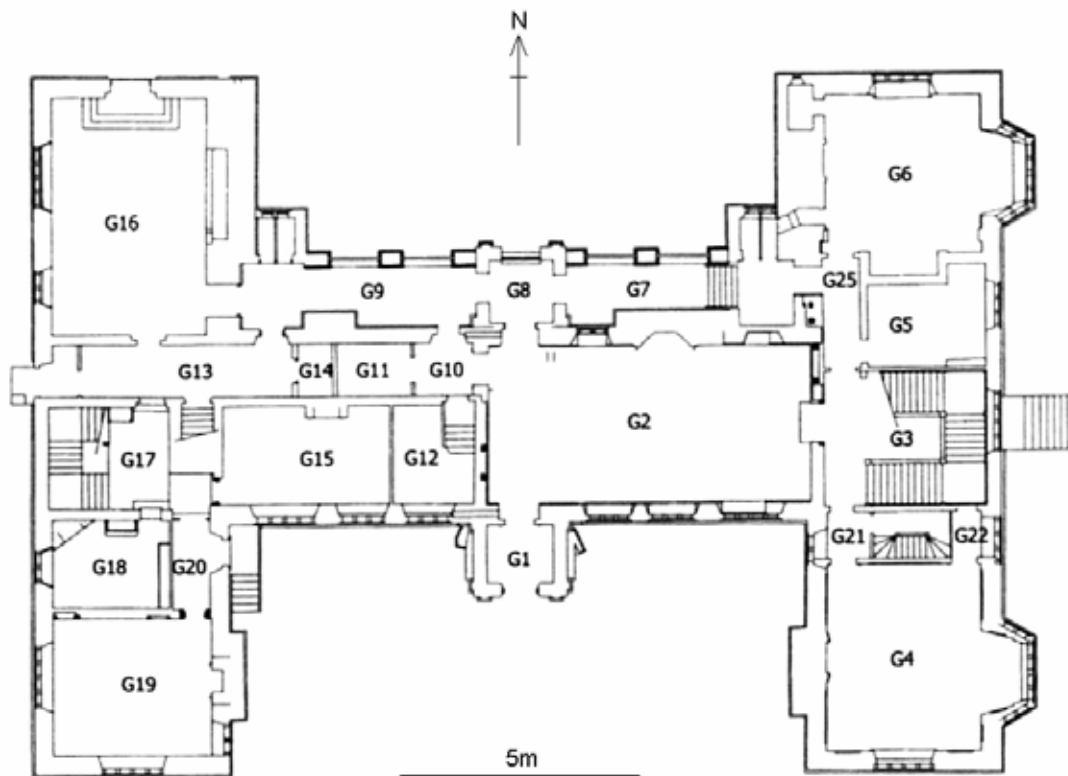
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## INTRODUCTION

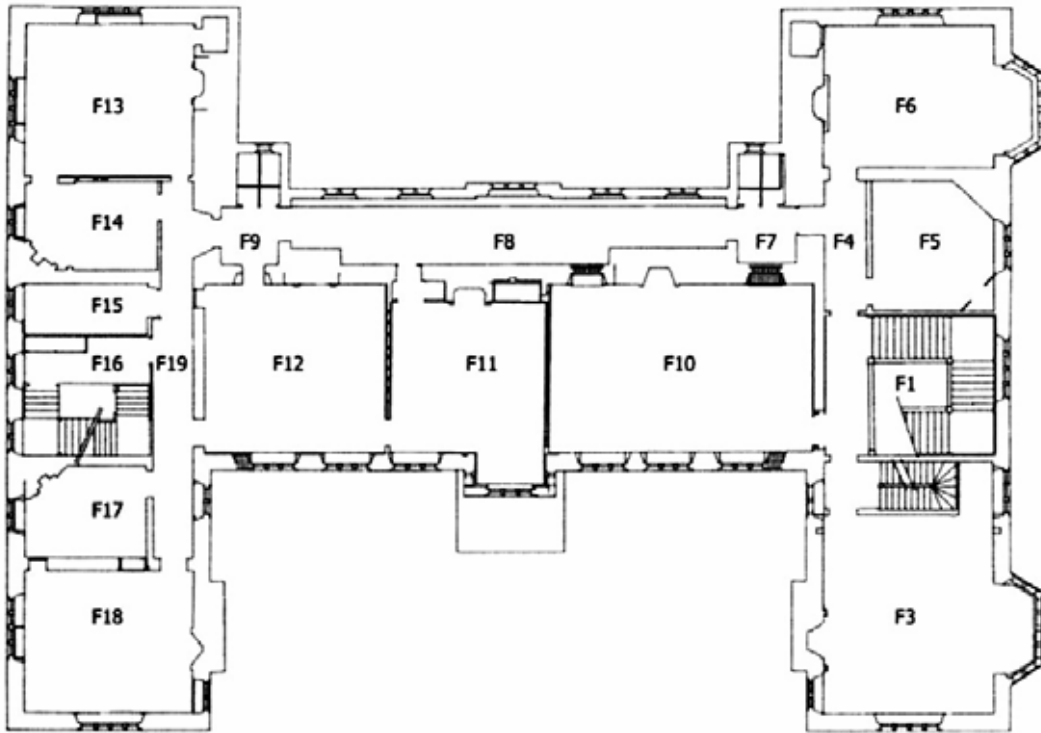
This report forms part of a larger project to characterise the chemical composition of historic window glass. The project has two primary aims: to better understand the nature of window glass manufacture in the last 500 years, and to provide a method to date the manufacture of extant window glass. The recent renovation of Shaw House, near Newbury, Berkshire (NGR SU 4757 6836) with National Lottery funding provided the opportunity to collect large numbers of samples of window glass from a single building (Heward and Yarham 2003). Shaw House was built by Thomas Dolman of Newbury between 1577 and 1581. Historical records suggest that building commenced in 1577 and several inscriptions on the building include the date of 1581. Dendrochronological dating of some of the roof timbers has shown that these were felled in the spring/summer of 1579 and 1580. Most of the fabric of the building belongs to a single phase, compatible with the 1581 date, and there are no indications that there was an earlier building on the site. A later Thomas Dolman made a series of alterations to the building at the end of the 17th century, including a new east stair. Thomas Dolman died in 1711 and the estate passed to the Duke of Chandos in 1728. After the early 18th century the house appears to have undergone no major rebuild.



*Figure 1. Plan of Shaw House (Ground floor) (Historic Building Surveys Ltd, 2003)*

A total of 133 samples of window glass were collected from several different rooms and under different circumstances. In many cases the window glass that was available consisted of fragments found near windows and uncovered when the wooden wall panelling was

removed. These fragments probably represent waste glass abandoned during earlier glazing and re-glazing activity. In some cases the glass fragments were taken from broken but *in situ* panes.



*Figure 2. Plan of Shaw House (First floor) (Historic Building Surveys Ltd, 2003)*

## METHODS

All of the glass fragments were catalogued, measured, weighed and 104 samples were chemically analysed. Colour was assessed by placing the fragments on a sheet of white paper. Samples were prepared for chemical analysis by embedding fragments (typically 5–10mm<sup>3</sup>) in epoxy resin so as to expose a cross-section through the thickness of the glass. The embedded samples were then ground with successively finer grades of silicon-carbide impregnated paper and polished with diamond abrasives, with the final polishing stage utilising a 3-micron diamond abrasive.

The chemical composition was determined using two different techniques. The main technique used (SEM-EDS) consisted of an energy dispersive detector (Oxford Instruments germanium detector with ISIS software) attached to a scanning electron microscope (Leica 440i operated with an excitation voltage of 25kV and a current of 1nAmp). Spectra were regularly calibrated against a cobalt standard and the raw analysed

data was calibrated against a suite of reference materials (including National Institute for Standards and Testing, Corning Museum, Society for Glass Technology and Deutsche Glastechnische Gesellschaft). The SEM-EDS technique employed has a relatively high detection limit for many heavier elements, especially some of those of particular interest for this project (eg iron, manganese, strontium and arsenic).

Low concentrations of heavier elements were determined using an EDAX Eagle II energy dispersive X-ray fluorescence spectrometer. This used an excitation voltage of 40kV, a current of 1mA in an atmosphere of normal air. Measured intensities were calibrated against the same suite of reference materials employed with the SEM-EDS analyses.

## GLASS TYPES

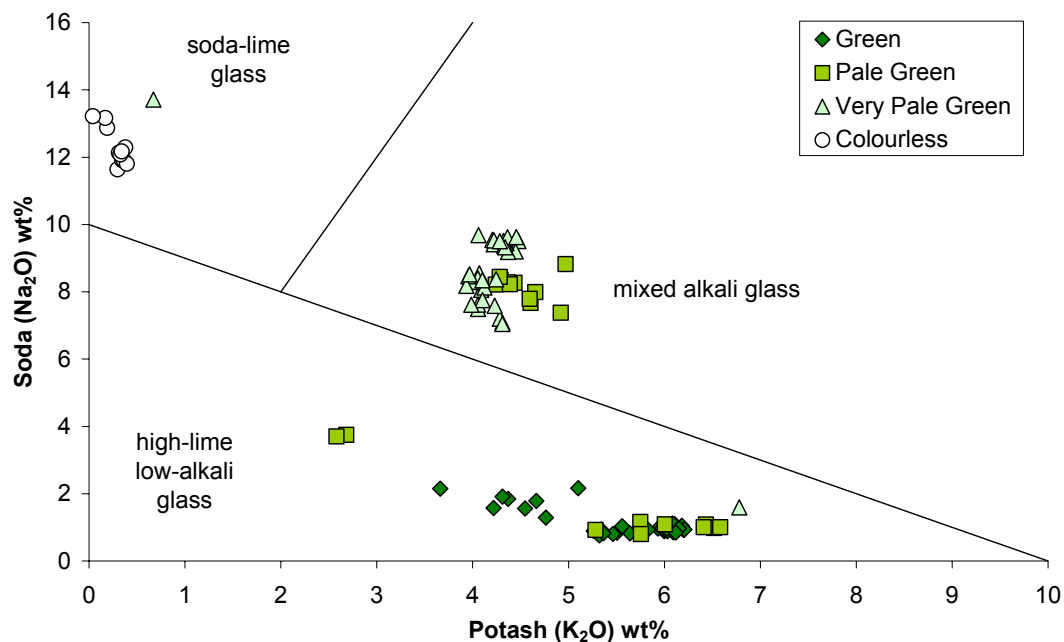


Figure 3. Plot of soda and potash content of all glass fragments analysed

The analysis of 104 fragments of window glass from Shaw House showed the use of three distinct types of glass (Figure 3). The first, and earliest, type of glass is a high-lime low-alkali (HLLA) glass which contains low concentrations of potash (3–7wt%) and very low concentrations of soda (1–4wt%). This glass is always has a distinct green tint (mostly described as green but also pale green) and is usually present as square- or diamond-shaped panes with grozed edges. The green tint is due to the presence of iron oxide (Figure 4) which may derive from the sand, the flux or both. The panes have sides up to 116mm in length, with an average thickness of 1.5mm (standard deviation of thickness 0.3mm). The production of HLLA glass in Britain starts in the late 16th century shortly before Shaw House was first built, and it continued to be produced until the end of the



19th century. The use of HLLA for the manufacture of window glass in most of Britain appears to have ceased around the beginning of the 18th century (it continued to be used for the manufacture of bottle glass until the end of the 19th century).

The second type of glass detected at Shaw House is a mixed alkali glass which has significant concentrations of both soda (7–10wt%) and potash (4–5wt%). One of the striking aspects of the mixed alkali glass is the relatively high strontium oxide content compared to the other glasses (Figure 4). This relatively high concentration of strontium is seen as evidence for the use seaweed ash (kelp) as a flux (see Dungworth *et al*/2009). This glass is less strongly coloured than HLLA glass and has been described here as pale green, pale blue-green, very pale green and very pale blue-green. The paler colour can be ascribed to the lower concentrations of iron oxide (Figure 4); there appear to be no additions of materials which would actively decolourise the glass. The mixed alkali glass is usually present as rectangular panes (mostly 154 by 258mm, or 6 by 10 inches) with an average thickness slightly less than that of the HLLA glass ( $1.4\pm 0.3\text{mm}$ ).

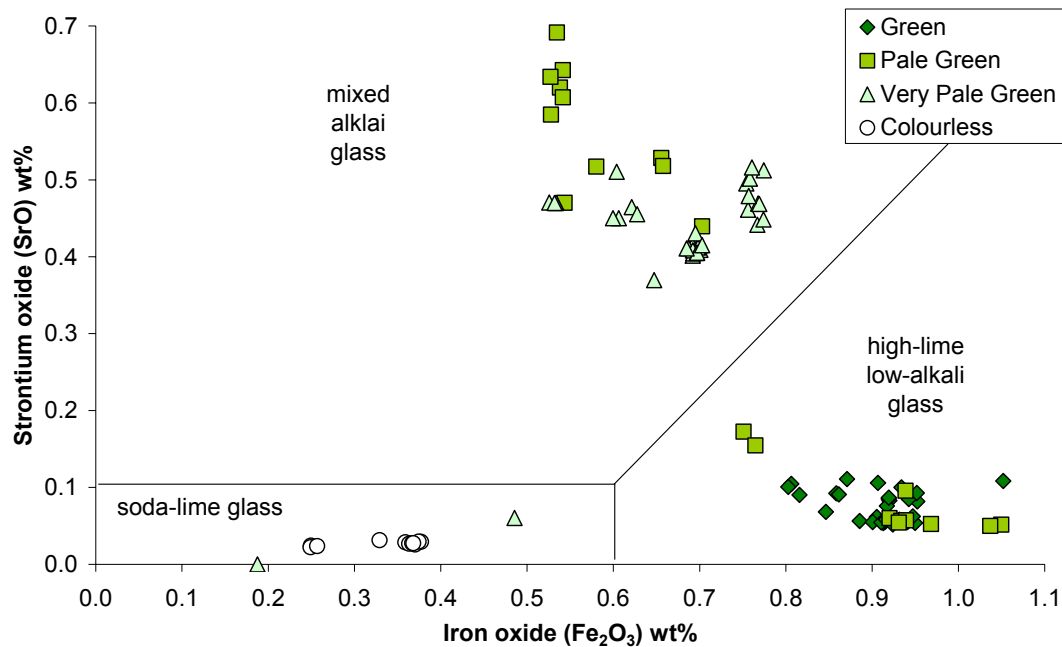


Figure 4. Plot of iron oxide and strontium oxide content of all glass fragments analysed

The final type of glass is a soda-lime glass of a type manufactured after the development of synthetic soda in the early 19th century. This glass contains high concentrations of soda (12–13wt%) and low levels of potash (<0.4wt%). The Leblanc process for transforming sodium chloride (eg sea salt) into soda ash (sodium carbonate) was introduced on an industrial scale in Britain c1830 and soda ash quickly supplanted the use of kelp and other plant-based fluxes. This glass contains very low concentrations of a range of oxides that are present in the two earlier (plant-based) glasses (especially phosphorus oxide). The soda-lime glass is mostly present as diamond panes and these appear to have been deliberately cut to fit into an existing glazing scheme (ie repairs). The soda-lime glass is



slightly thinner than the earlier glass types and shows slightly less variation in thickness ( $1.2\pm 0.2\text{mm}$ ). It contains appreciable concentrations of both manganese and arsenic which were probably deliberately added to decolourise the glass (counteract the colouring effect of the iron oxide).

## ROOM B6

B6 is not marked on the plan (Figure 1) but is a basement room underneath G7 and G25 (which are marked). Six fragments of glass were recovered *in situ* from a blocked window on the east side of B6 (Figure 5). This window was inserted towards the end of the 17th century but was blocked by 1730 (Morris 2006). The six fragments of glass from B6 included a single fragment (73) of mixed alkali glass and five (74–78) of HLLA glass. The mixed alkali glass fragment has a composition which does not provide a close match with any of the window glass fragments from any other rooms. The five fragments of HLLA glass include two joining fragments, which have almost identical compositions. The remaining samples, however, are sufficiently different from each other and from window glass fragments from other rooms to be sure that they do not relate to a single pane or batch.



Figure 5. Window glass from the blocked window on the east side of B6

## ROOM G2: THE HALL



Figure 6. Green glass from G2



Figure 7. Other glass from G2

This room was completely refitted between 1680 and 1700; there are no later records of building/alteration. In total, 28 fragments of glass were collected from near the windows (having been revealed after the removal of the wooden wall panelling). Eighteen of these fragments were distinctly green in colour (Figure 6), eight were pale green, one was very pale blue-green and one was colourless (Figure 7). All of the green glass was HLLA glass. Despite having almost identical compositions, the pieces show subtle differences indicating the presence of two batches of glass (Figure 8). The first group (samples 1, 4, 7, 8, 10, 11, 14, 15 and 16) contains less silica and more lime than the second group (2, 3, 3, 5, 6, 9, 12, 13, 17 and 18). The fragments were collected from the vicinity of several windows in G2 and no joins were found between any of the fragments; it is therefore unlikely that these two groups derive simply from two panes of glass. The similarities between the two groups suggest that were made in the same workshop, while the differences suggest they were made from different batches of glass on different days.

The remaining glass from G2 includes six fragments of mixed alkali glass (19, 21, 23, 25, 26 and 27) with virtually identical compositions: none of the samples varies from the average by more than the analytical precision. Three of these fragments clearly join each other (19, 21 and 23) and the other three fragments are small enough that they may derive from the same pane. Two of the remaining fragments are mixed alkali glass but with compositions that are distinct from the first mixed alkali glass. The final two fragments of glass from G2 (20 and 24) are soda-lime glasses. One of these (24) contains negligible concentrations of magnesia but is decolourised with arsenic. The use of arsenic as a decolouriser probably places manufacture between c1820 and c1900. The second fragment of glass (20) contains several weight percent of magnesia (and lower lime) but no arsenic. The use of a soda-lime glass recipe with reduced lime but some magnesia (as in this sample) is a characteristic of cylinder glass produced by automated processes (Cable 1991; 2004) and this glass was probably produced after c1920.

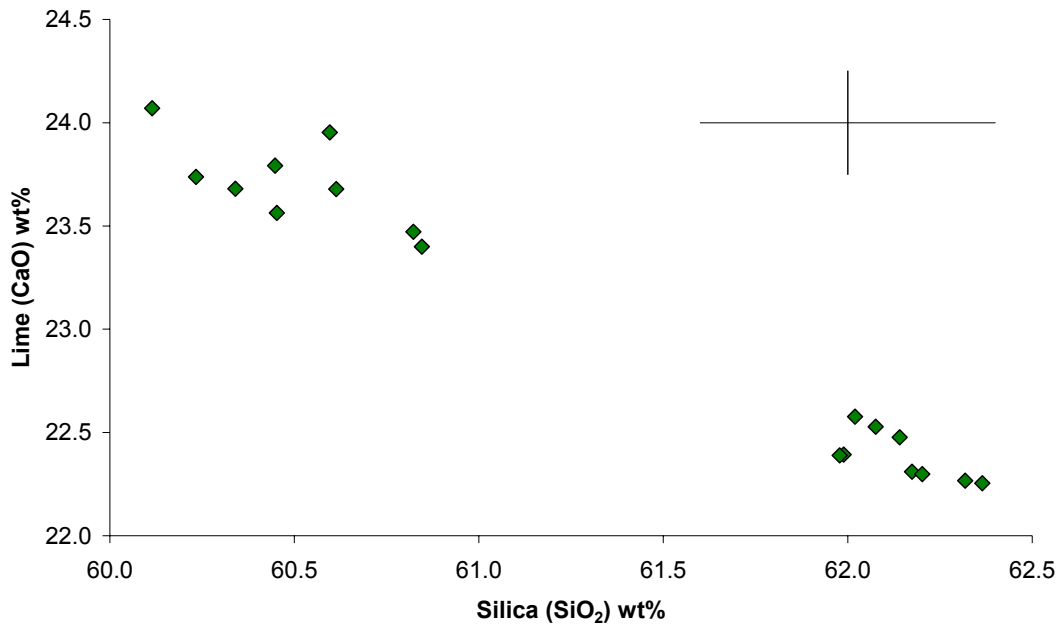


Figure 8. Silica and lime content of the HLLA glass from Room G2 (the cross indicates the precision of the analytical technique for the two oxides displayed)

## ROOM G3

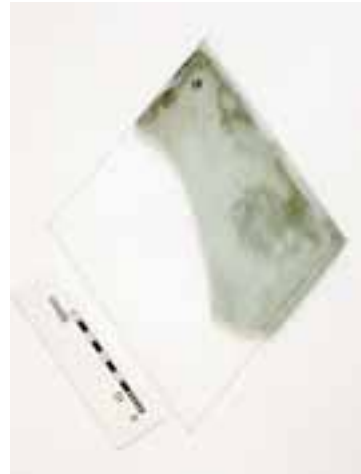
In total, eleven fragments of glass were collected from near the windows (having been revealed after the removal of the wooden wall panelling). Six of these fragments were distinctly green in colour (Figure 9), while the remainder were pale green (Figure 10). Most of the green glass fragments derived from diamond panes (Figure 9) with internal angles of 75° and 105° and sides of 105–125mm (4 to 5 inches). All of the green glass (30, 31, 32, 33, 34 and 40) was HLLA glass, with sufficient differences between fragments to suggest that none derived from the same pane or batch. Despite this, all samples shared compositional similarities that contrasted with the HLLA glass of G2 to suggest a different source. In particular, the G2 HLLA glass contains much higher concentrations of manganese oxide, titanium oxide and zirconium oxide. The first of these oxides probably derives from the plant ash flux while the second two reflect the composition of the sand used. The differences are sufficient to suggest very different locations for the relevant HLLA glass houses (assuming that the two putative glasshouses employed local resources).

The five fragments of pale glass from G3 include two fragments (35 and 36), which while being HLLA glass, have rather unusual compositions. These fragments contain more soda and strontium oxide than any of the other HLLA glass fragments suggesting that the flux included a proportion of kelp. One of these fragments of glass has an inscribed image (Figure 11). This appears to show a castle or other major building with an entrance

flanked by two towers or wings. It is difficult to know whether or not this is meant to be a representation of Shaw House.



*Figure 9. Dark green HLLA glass from G3*



*Figure 10. Pale green mixed alkali glass from G3*



*Figure 11. Inscribed design on fragment 35 showing a stylised castle or grand house with two towers or wings flanking an entrance (image width = 13mm)*

The remaining fragments (37–39) are pale green glass from panes of similar size and shape as the green HLLA glass from the same room (Figure 9). The mixed alkali glass was made using kelp as a flux but the compositions of each fragment are sufficiently different to suggest that none were from a single pane or batch. Nevertheless these three

fragments have more in common with each other than with the mixed alkali glass from Room G2 (in particular the alumina contents are markedly different).

## ROOM G6

A single sample of glass was found in Room G6 (not *in situ*). This was a HLLA glass which had a composition which did not match any of the HLLA glass from other rooms.

## ROOM F1

Room F1 was significantly altered by the changes which occurred at the end of the 17th and beginning of the 18th centuries. The twenty fragments of very pale green glass were recovered *in situ* from six panes (Figure 12, rectangular 150 by 225mm, 6 by 11 inches, and 1.6mm thick). It is most unlikely that any of these panes predate the c1690–c1720 alterations.



Figure 12. Window glass pane number 2 from Room F1

Table 1. Details of the samples from Room F1

Pane	Samples
1	90, 91, 92, 93
2	94, 95, 96, 97
3	98, 102, 103
4	99, 100
5	105, 106
6	107, 108, 109, 110, 111

The chemical analysis of the twenty fragments of glass from six panes indicates that all were made from a mixed alkali glass and that there are two distinct compositional groups present. Panes 1, 2, 3 and 6 all share virtually identical compositions: the variation in composition between the different panes is similar to the variation between fragments from a single pane, and in both cases the variation is barely more than the analytical precision (Figure 13). Panes 4 and 5 share a similar composition but this is distinct from that of the other panes.

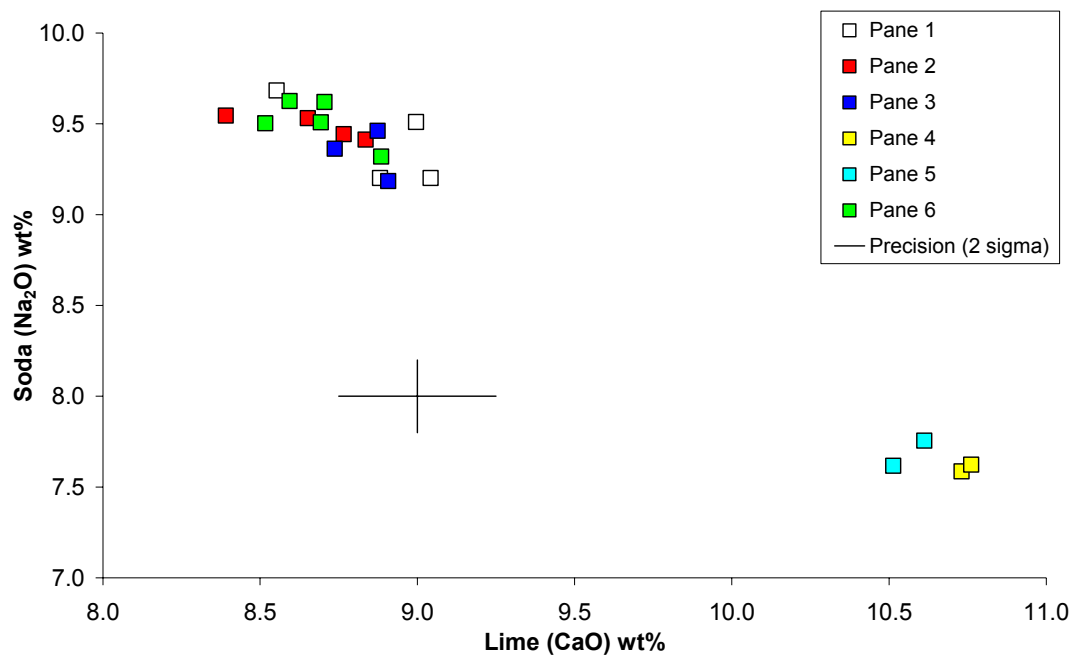
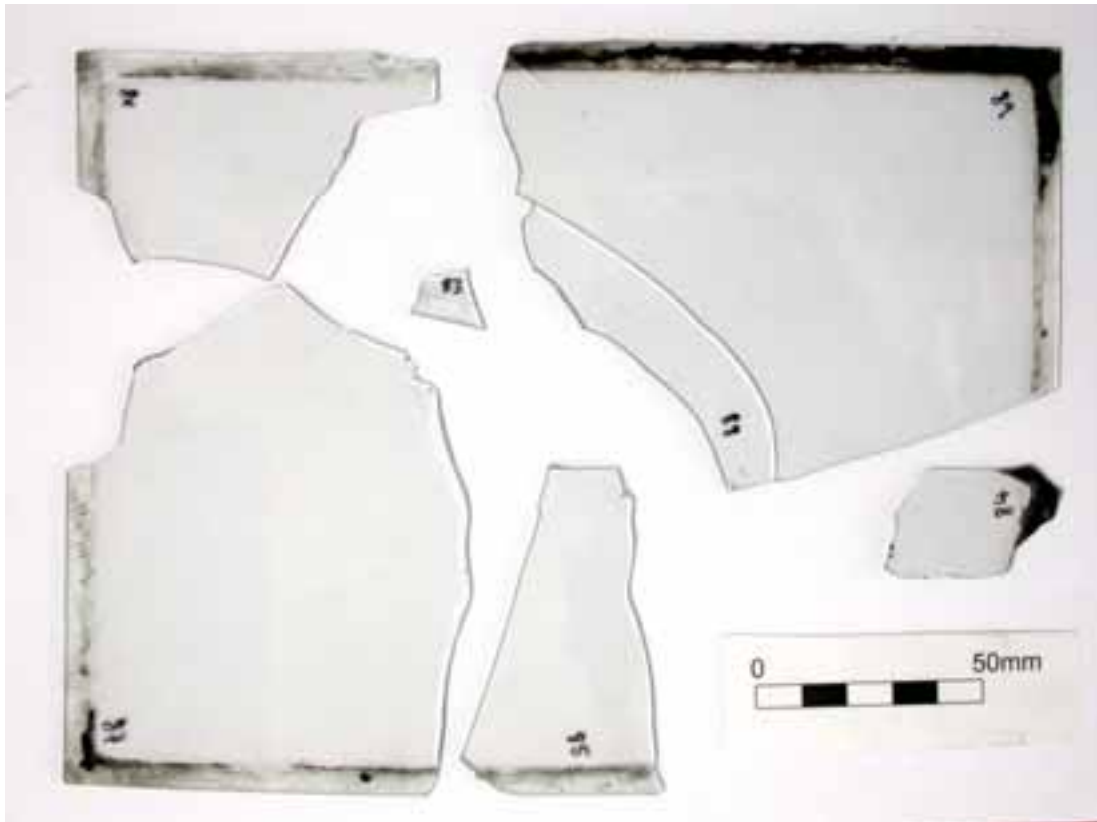


Figure 13. Plot of potash and soda concentrations for the 20 fragments of glass from Room F1



## ROOM F3

Room F3 was significantly altered in 1728–30. Seven fragments of colourless glass from square or rectangular panes (with at least one side in excess of 125mm) were recovered from this room (although none were *in situ*). All seven fragments are soda-lime glasses which share virtually identical chemical compositions (the samples vary from the average composition by less than the analytical precision). Although only two fragments were found to join, it is possible that all seven fragments derived from a single pane of glass. The fact the glass is a soda-lime glass with low levels of oxides (especially phosphorus oxide) usually associated with plant ash fluxed glasses (such as HLLA and kelp mixed alkali glass) makes it certain that the glass was manufactured after the introduction of the Leblanc process soda ash (c1830). The low levels of magnesia indicate that the glass was probably produced before c1920 when the automated cylinder process was introduced. The presence of arsenic in this glass indicates that it was probably produced before c1900.



*Figure 14. Window glass from Room F3*



## ROOM F6

Room F6 is known to have had sash windows installed in the 1730s. Seven fragments of glass were recovered from this room (none *in situ*). The analysis of three fragments showed them to be soda-lime glasses. The three samples share very similar compositions and could easily be the product of a single batch (or possibly a single pane). The glass composition clearly places manufacture after the introduction of the Leblanc process (c1830). The low levels of magnesia make it almost certain that manufacture occurred before the introduction of automated cylinder production (c1920). In addition the use of arsenic as a decolouriser would place manufacture before c1900.



*Figure 15. Window glass from Room F6*

Despite the visual similarity between the colourless soda-lime glass from rooms F3 (Figure 14) and F6 (Figure 15) there are sufficient differences in the composition to suggest that they do not belong to a single batch and probably do not indicate a single phase of re-glazing in the 19th century.

## ROOM F13



*Figure 16. Green and very pale green glass from Room F13*

The documentary evidence indicates that Room F13 (in the western wing) was not included in the 1730s alterations (including the re-glazing of most of the rooms in the eastern wing). Sixteen samples of glass were recovered from Room F13: six green (or blue-green) and ten very pale green fragments. The green glass was all HLLA glass with a slight spread of compositions suggesting several batches (but probably from a single source or production centre). In general, the F13 HLLA glass has compositional similarities with the first group of HLLA glass from G3, including relatively high concentrations of manganese oxide, titanium oxide and zirconium oxide.

All of the very pale green glass fragments from F13 are mixed alkali glass which share virtually identical compositions (the variations from the average are less than the analytical precision). No joins were noted among these fragments but they are all small (Figure 16) and could possibly derive from a single pane. The F13 mixed alkali glass has a similar

composition to that from Room G2 but there are sufficient differences to suggest that they belong to different batches (and possibly from different glasshouses).

## ROOM F18



Figure 17. Window glass from Room F18

Room F18 is recorded as having sash windows installed in the 1730s. Eight samples of green and pale green glass were recovered (none *in situ*) from this room and all were HLLA glasses. Three of the samples (50, 51 and 53) share virtually identical compositions, however, none of the remaining fragments have sufficiently similar compositions to be regarded as belonging to the same batch. None of the HLLA glass from Room F18 matched closely to any of the HLLA glass from other rooms.

## ROOM S18



Figure 18. 14 of the 26 window glass fragments from a single pane from Room S18

Twenty-six fragments of very pale blue-green glass from a single pane were recovered from Room S18 (second floor plan not available). The analysis of four fragments showed that the pane was made from a mixed alkali glass but with a chemical composition which did not exactly match that of any of the other rooms.

### SUMMARY: WINDOW GLASS AT SHAW HOUSE

The chemical analysis of large numbers of window glass fragments from Shaw House shows the use of three major glass types: HLLA, mixed alkali and soda-lime. The results indicate that the collection of samples *in situ* (ie from B6 and F1) provide data that is of use for the construction of a chronological model. Where glass was not *in situ*, however, there was no information about the date of manufacture beyond the simplest level that the house was built 1577–81 and that re-glazing could have occurred at any time up to the end of the 20th century. This limitation is illustrated most clearly by Room G2 which yielded a wide range of glass types, including some (the HLLA) which was probably manufactured prior to c1700 and one fragment which must have been manufactured after c1920.

The contrast between the predominantly HLLA glass of the blocked window in B6 and the exclusively mixed alkali glass of F1 suggests a significant change in window glass manufacturing technology at about the time that the major changes took place in the east wing (c1700). This theory finds support in data collected from other sites (see below).

Although the analysis of the bulk of the window glass fragments contributes little to the formation of a chronological model, the sheer number of analyses provides some information about the provision of glass to a major country house. While some rooms yielded groups of fragments with virtually identical compositions (eg the HLLA in G2 or the mixed alkali in F1), it was not possible to identify any identical glass in different rooms. This suggests that window glass production technology before c1920 (the likely date of manufacture of all but one sample) was such that an identical glass composition could not be maintained for a production run sufficient to glaze more than one room. Indeed, the two HLLA glasses of G2 are sufficiently close in chemical composition to almost certainly have been produced in the same glasshouse but are sufficiently different to have been produced at different times (although perhaps only days apart). The same is possibly true for the two mixed alkali glasses detected among the F1 window glass. Among the HLLA glasses there are two distinct but broad groups which can be distinguished on the basis of the manganese, titanium and zirconium contents. The differences are such that it is likely that the two groups represent supply from two different production centres in geologically distinct regions of the country.

## DISCUSSION: A CHRONOLOGICAL MODEL FOR CHANGES IN WINDOW GLASS

The results of the chemical analysis compliment and strengthen results from elsewhere and allow the construction of a tentative chronological model for the manufacture of window glass from the Middle Ages to the 20th century. The chronological model assumes that technological changes were rapidly transmitted through the glass industry and that new recipes quickly supplanted old ones. Many new recipes are characterised by greater transparency (due to the use of ingredients which contained less iron) and it is this that is likely to have ensured that older recipes were largely abandoned.

The earliest phase of window glass production in Britain (up to c1567) was based on the production of so-called forest glass. It is likely that this was made using sand and bracken ash to produce a potash-lime glass characterised by relatively high levels of a wide range of minor oxides, eg magnesia and phosphorus oxide.

The HLLA phase of window glass production (c1567 to c1700) begins with the arrival of French glassmakers who brought a number of technological changes including a new glass recipe: high-lime low-alkali glass. HLLA glass appears to have been produced using sand and the ash of hardwoods (especially oak). The production of forest glass appears to have

continued for only a few years or decades after the first production of HLLA glass in Britain (Dungworth and Clark 2004). HLLA glass was produced in continental Europe for at least a century before it was introduced to Britain, and it was probably imported before c1567.

The mixed alkali glass phase (c1700 to c1830) was based on the use of seaweed ash (kelp) and sand (possibly with the addition of some lime). The production of mixed alkali glass was introduced by the 1660s (Dungworth and Cromwell 2006) but it appears to have been used only for the production of tablewares prior to the end of the 17th century. The glass used for a window at Palace House Mansion, Newmarket, which was blocked at the end of the 17th century, was HLLA (Bayley *et al*/2009). The analysis of window glass fragments from Silkstone, from contexts dated to 1700–30, included two HLLA and ten mixed alkali (Dungworth 2006). The analysis of debris from several 18th-century crown glass production sites indicates that mixed alkali glass (with significant amounts of strontium) continued to be used until at least the late 18th century (Dungworth 2007; Dungworth and Mortimer 2005). Similarly, 18th-century documentary evidence points to the widespread use of kelp (Watson 1782). No analyses of early 19th-century window glass are available but documentary evidence suggests that kelp continued to be the main stay of the window glass industry until the introduction of the Leblanc soda process c1830.

The Leblanc process was the first of several methods of producing pure sodium compounds (usually from salt) which came to dominate the glass industry from c1830. Since then almost all window glass has been made using silica sand, soda ash (or sodium sulphate) and lime. Nevertheless, there is a wealth of documentary evidence which suggests that various technological changes in the 19th and early 20th centuries would have had an impact on the chemical composition of the glass produced. Only those which have been detected through the chemical analysis of historic samples are discussed here.

The first phase comprises a soda-lime glass to which arsenic has been added as a decolouriser. There are contemporary 19th-century references to glassmaking which mention the use of arsenic as a decolouriser. Ure (1844), Muspratt (1860) and Powell *et al* (1888) all refer to the use of arsenic in the manufacture of window glass, but according to Marson (1918) and Rosenhain (1919) its use in window glass was abandoned by the early 20th century. The analysis of glassworking materials from Nailsea shows that arsenic was in use as a decolouriser by 1837 (Hatton 2004). It is not clear yet when arsenic began to be added window glass, although Parkes (1823) writing within a few years of the introduction of synthetic soda, mentions arsenic as a decolouriser, but only in relation to flint (ie lead) glass.

From c1900 to c1920 the soda-lime glass recipe of the 19th century (but without the addition of arsenic) continued to be employed in the manufacture of window glass. From c1920 various automatic techniques were adopted widely in the glass industry. These techniques allowed the production of large sheets of glass but their sheer size and the

time required to manipulate them meant that they tended to devitrify. This problem was overcome by using a small amount of magnesia in place of a portion of the lime (Cable 1991; 2004).

The above discussion has demonstrated that there are grounds for the use of chemical analysis of historic window glass as a means of broadly dating the period of its production. It is now possible to suggest that a particular pane of glass was manufactured before or after a particular date (eg c1700, c1830, c1900 or c1920). Nevertheless the technique is still being developed and requires further analysis of well-dated specimens.

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## APPENDIX 1: DETAILS OF GLASS ANALYSED

For the room numbers refer to Figures 1 and 2.

Shape: S = square (or rectangular); D = diamond

No.	Room	Thickness	Colour	Cutting	Comments	Shape
1	G2	1.25±0.05	Green	Grozed		S
2	G2	2.75±1.25	Green	Grozed	Pontil scar and bull's eye	S
3	G2	1.65±0.05	Green	Grozed		S
4	G2	1.45±0.05	Green	Grozed		S
5	G2	1.50±0.10	Green	Grozed		S
6	G2	1.35±0.05	Green	Grozed		S
7	G2	1.05±0.15	Green	Grozed		S
8	G2	1.45±0.15	Green	Grozed		S
9	G2	1.45±0.05	Green	Grozed	Surface ridges	S
10	G2	1.70±0.20	Green	Grozed	Surface ridges	S
11	G2	1.45±0.05	Green	Grozed		S
12	G2	1.55±0.05	Green	Grozed		S
13	G2	1.65±0.05	Green	Grozed		S
14	G2	1.35±0.05	Green	Grozed		S
15	G2	1.60±0.00	Green	Grozed		S
16	G2	1.40±0.10	Green			S
17	G2	1.65±0.05	Green	Grozed		S
18	G2	1.45±0.05	Green			S
19	G2	1.15±0.05	Pale green	Diamond	joins 21	S
20	G2	1.70±0.00	Very pale blue-green	Diamond		S
21	G2	1.15±0.05	Pale green	Diamond	joins 19 & 23	S
22	G2	1.90±0.00	Pale green	Diamond		S
23	G2	1.15±0.05	Pale green		joins 21	S
24	G2	1.40±0.10	Colourless			S
25	G2	1.10±0.10	Pale green	Diamond		S
26	G2	1.10±0.00	Pale green	Diamond		S
27	G2	1.10±0.00	Pale green			S
28	G2	1.85±0.05	Pale green			S
30	G3	1.75±0.15	Green	Grozed		D
31	G3	1.70±0.30	Green	Grozed	complete length	D
32	G3	1.40±0.20	Green	Grozed	complete length	D
33	G3	1.80±0.00	Green	Grozed		D
34	G3	1.55±0.05	Green	Grozed		D
35	G3	1.60±0.00	Pale green	?	Castle doodle	D
36	G3	1.60±0.00	Pale green	Diamond		D
37	G3	1.40±0.20	Pale green	Diamond		D
38	G3	1.25±0.15	Pale green	Diamond		D
39	G3	1.40±0.00	Pale green	Diamond		D
40	G3	1.50±0.10	Green	?	Originally still in lead; complete	D
41	F6	1.20±0.20	Colourless	Diamond		S
42	F6	1.25±0.05	Colourless	Diamond		S
43	F6	1.15±0.05	Colourless	Diamond		S
48	F18	1.70±0.20	Green	Grozed	wobbly	D
49	F18	0.90±0.00	Pale green	Grozed		D
50	F18	1.10±0.10	Pale green			D

No.	Room	Thickness	Colour	Cutting	Comments	Shape
51	F18	1.10±0.10	Pale green	Diamond		D
52	F18	1.10±0.00	Green	Grozed		D
53	F18	1.05±0.05	Pale green	Diamond		D
54	F18	1.95±0.05	Green			D
55	F18	1.40±0.10	Green	Grozed	wobbly	D
56	F13	1.05±0.05	Green			?
57	F13	1.65±0.05	Green	Grozed		?
58	F13	1.60±0.10	Green	Grozed		D
59	F13	1.65±0.05	Blue-green	Grozed		?
60	F13	1.25±0.05	Green	Grozed		?
61	F13	0.95±0.05	Green	Diamond		?
62	F13	1.35±0.05	Very pale green	Diamond		?
63	F13	1.40±0.00	Very pale green			?
64	F13	1.25±0.05	Very pale green			?
65	F13	1.05±0.05	Very pale green			?
66	F13	1.15±0.05	Very pale green			?
67	F13	1.50±0.00	Very pale green			?
68	F13	1.20±0.00	Very pale green			?
69	F13	1.20±0.00	Very pale green			?
70	F13	1.00±0.00	Very pale green		Blob of glass on surface	?
71	F13	1.00±0.00	Very pale green			?
72	G6	1.20±0.10	Green			?
73	B6	1.20±0.10	Very pale blue-green			?
74	B6	1.60±0.10	Pale green	Diamond	joins 75	D
75	B6	1.65±0.05	Pale green	Diamond	joins 74	D
76	B6	1.25±0.05	Pale green	Grozed		D
77	B6	1.65±0.15	Pale green	Diamond		D
78	B6	1.70±0.30	Very pale green	Grozed		D
79	S18	1.05±0.05	Very pale blue-green	Diamond	26 frag from single pane	S
80	S18	1.05±0.05	Very pale blue-green	Diamond	26 frag from single pane	S
81	S18	1.05±0.05	Very pale blue-green	Diamond	26 frag from single pane	S
82	S18	1.05±0.05	Very pale blue-green	Diamond	26 frag from single pane	S
83	F3E	1.20±0.00	Colourless	Diamond		S
84	F3E	1.15±0.05	Colourless	Diamond		S
85	F3E	1.15±0.05	Colourless	Diamond		S
86	F3E	1.10±0.00	Colourless	Diamond		S
87	F3E	1.15±0.05	Colourless	Diamond		S
88	F3E	1.20±0.00	Colourless	Diamond	joins 88	S
89	F3E	1.30±0.10	Colourless	Diamond	joins 89	S
90	F1	1.55±0.05	Very pale green	Diamond	joins 90-93 (inscribed CH or GM)	S
91	F1	1.60±0.10	Very pale green	Diamond	joins 90-93 (inscribed CH or GM)	S
92	F1	1.80±0.20	Very pale green	Diamond	joins 90-93 (inscribed CH or GM)	S
93	F1	2.10±0.10	Very pale green	Diamond	joins 90-93 (inscribed CH or GM)	S
94	F1	1.60±0.10	Very pale green	Diamond	joins 94-97	S
95	F1	1.45±0.15	Very pale green	Diamond	joins 94-97	S
96	F1	1.35±0.05	Very pale green	Diamond	joins 94-97	S
97	F1	1.45±0.05	Very pale green	Diamond	joins 94-97	S
98	F1	1.65±0.25	Very pale green	Diamond		S
99	F1	1.50±0.10	Very pale green	Diamond		S
100	F1	1.50±0.10	Very pale green	Diamond		S
102	F1	1.45±0.05	Very pale green	Diamond		S

No.	Room	Thickness	Colour	Cutting	Comments	Shape
103	F1	1.75±0.25	Very pale green	Diamond		S
105	F1	1.55±0.05	Very pale green	Diamond	joins 106	S
106	F1	1.50±0.10	Very pale green	Diamond	joins 105	S
107	F1	1.60±0.10	Very pale green	Diamond	joins 107-111	S
108	F1	1.55±0.05	Very pale green	Diamond	joins 107-111	S
109	F1	1.60±0.10	Very pale green	Diamond	joins 107-111	S
110	F1	1.75±0.05	Very pale green	Diamond	joins 107-111	S
111	F1	1.75±0.05	Very pale green	Diamond	joins 107-111	S

## APPENDIX 2: CHEMICAL COMPOSITION OF THE GLASS

No.	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	ZnO	As <sub>2</sub> O <sub>3</sub>	SrO	ZrO <sub>2</sub>	BaO
1	1.10	2.32	2.36	60.45	2.16	0.38	0.21	6.10	23.56	<0.1	0.12	0.91	0.02	<0.05	0.06	0.01	0.16
2	0.95	2.24	2.27	62.36	2.13	0.31	0.12	6.06	22.25	0.13	0.12	0.94	0.02	<0.05	0.06	0.01	<0.1
3	0.88	2.19	2.29	62.32	2.17	0.46	0.15	6.00	22.27	0.13	0.13	0.91	0.02	<0.05	0.06	0.01	<0.1
4	0.92	2.21	2.26	60.61	2.41	0.38	0.16	6.20	23.68	<0.1	0.11	0.89	0.02	<0.05	0.06	0.01	<0.1
5	0.98	2.17	2.26	61.98	2.10	0.49	0.14	6.14	22.39	0.19	0.12	0.92	0.02	<0.05	0.06	0.02	<0.1
6	0.98	2.17	2.26	61.99	2.10	0.49	0.14	6.14	22.39	0.19	0.13	0.92	0.02	<0.05	0.06	0.01	<0.1
7	0.91	2.20	2.25	60.60	2.27	0.40	0.16	6.08	23.95	<0.1	0.11	0.90	0.02	<0.05	0.06	0.02	<0.1
8	1.04	2.27	2.39	60.11	2.19	0.31	0.16	6.18	24.07	0.13	0.11	0.92	0.02	<0.05	0.06	0.01	<0.1
9	0.97	2.20	2.34	62.20	2.19	0.40	0.11	5.93	22.30	<0.1	0.12	0.93	0.02	<0.05	0.06	0.01	0.12
10	0.85	2.27	2.39	60.45	2.30	0.45	0.13	6.09	23.79	0.14	0.11	0.91	0.02	<0.05	0.06	0.01	<0.1
11	1.11	2.25	2.38	60.34	2.24	0.42	0.17	6.08	23.68	0.17	0.12	0.92	0.02	<0.05	0.06	0.01	<0.1
12	0.96	2.16	2.28	62.08	2.21	0.36	0.16	5.97	22.53	0.13	0.12	0.92	0.02	<0.05	0.06	0.01	<0.1
13	0.93	2.11	2.33	62.17	2.13	0.48	0.16	6.00	22.31	0.18	0.13	0.94	0.02	<0.05	0.06	0.01	<0.1
14	0.89	2.34	2.39	60.85	2.29	0.34	0.14	6.03	23.40	0.16	0.12	0.95	0.02	<0.05	0.06	0.01	<0.1
15	0.94	2.17	2.25	60.82	2.28	0.35	0.17	6.21	23.47	0.15	0.12	0.95	0.02	<0.05	0.06	0.01	<0.1
16	0.96	2.26	2.35	60.23	2.37	0.40	0.17	6.15	23.74	<0.1	0.11	0.92	0.02	<0.05	0.05	0.01	0.12
17	0.95	2.12	2.23	62.14	2.17	0.41	0.17	6.03	22.48	0.11	0.13	0.93	0.02	<0.05	0.06	0.02	<0.1
18	0.85	2.12	2.26	62.02	2.16	0.37	0.15	6.12	22.58	0.13	0.12	0.93	0.02	<0.05	0.06	0.01	0.11
19	8.36	5.53	2.39	65.38	1.37	0.19	0.74	4.29	10.34	<0.1	0.04	0.53	<0.02	<0.05	0.67	0.03	<0.1
20	13.71	2.70	1.63	71.96	<0.1	0.21	0.11	0.67	8.69	<0.1	<0.02	0.19	<0.02	<0.05	<0.01	<0.01	<0.1
21	8.27	5.23	2.35	65.61	1.42	0.12	0.68	4.44	10.42	0.21	0.04	0.54	<0.02	<0.05	0.60	0.02	<0.1
22	7.67	5.11	3.20	66.68	0.90	0.20	0.46	4.60	9.80	<0.1	0.07	0.66	<0.02	<0.05	0.51	0.02	<0.1
23	8.28	5.51	2.32	65.42	1.41	0.12	0.72	4.37	10.43	0.18	0.04	0.54	<0.02	<0.05	0.59	0.02	<0.1
24	12.29	0.19	1.33	69.52	<0.1	0.58	<0.1	0.38	13.76	<0.1	0.33	0.33	<0.02	0.10	0.03	<0.01	<0.1
25	8.21	5.41	2.36	65.57	1.34	0.19	0.79	4.24	10.49	0.13	0.04	0.54	<0.02	<0.05	0.62	0.02	<0.1
26	8.23	5.33	2.37	65.84	1.20	0.15	0.76	4.39	10.42	0.12	0.04	0.53	<0.02	<0.05	0.57	0.02	<0.1
27	8.44	5.53	2.36	65.46	1.42	<0.1	0.77	4.28	10.27	0.15	0.04	0.53	<0.02	<0.05	0.61	0.02	<0.1
28	7.99	4.90	3.23	66.82	0.73	0.20	0.47	4.65	9.65	<0.1	0.06	0.66	<0.02	<0.05	0.50	0.02	<0.1

No.	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	ZnO	As <sub>2</sub> O <sub>3</sub>	SrO	ZrO <sub>2</sub>	BaO
30	1.85	2.73	2.27	62.87	2.23	0.18	0.40	4.37	20.78	0.39	0.69	0.92	0.03	<0.05	0.09	0.04	0.13
31	0.82	3.46	2.26	60.94	2.09	0.23	0.11	5.64	21.71	0.38	0.89	0.81	0.03	<0.05	0.11	0.02	0.25
32	1.56	3.07	2.69	59.52	2.82	0.13	0.42	4.55	22.63	0.38	0.72	0.95	0.03	<0.05	0.08	0.03	0.15
33	1.91	3.01	2.27	62.52	2.03	0.11	0.47	4.31	20.65	0.43	0.68	0.92	0.03	<0.05	0.08	0.04	0.15
34	0.94	3.45	2.18	61.24	2.10	0.14	0.11	5.83	21.57	0.25	0.88	0.80	0.03	<0.05	0.10	0.02	0.32
35	3.75	2.71	1.97	64.19	1.16	0.36	0.37	2.68	21.44	<0.1	0.12	0.75	<0.02	<0.05	0.17	0.02	0.19
36	3.70	2.49	2.07	64.22	1.39	0.18	0.46	2.58	21.68	0.15	0.12	0.76	<0.02	<0.05	0.15	0.02	<0.1
37	7.37	5.09	4.02	66.35	0.76	0.15	0.47	4.92	9.55	<0.1	0.07	0.70	<0.02	<0.05	0.43	0.01	<0.1
38	8.82	5.27	3.09	64.73	0.87	0.30	0.43	4.97	10.15	0.15	0.07	0.58	<0.02	<0.05	0.50	0.02	<0.1
39	7.79	4.79	3.31	67.06	0.87	<0.1	0.58	4.60	9.80	<0.1	0.05	0.54	<0.02	<0.05	0.46	0.02	<0.1
40	1.79	3.01	2.74	59.84	2.54	0.26	0.44	4.66	22.18	0.39	0.71	0.94	0.03	<0.05	0.09	0.04	<0.1
41	12.87	0.08	0.88	70.44	<0.1	0.45	0.15	0.19	13.24	<0.1	0.40	0.25	<0.02	0.08	0.03	<0.01	<0.1
42	13.17	0.25	0.83	70.40	<0.1	0.41	0.15	0.17	13.06	<0.1	0.40	0.25	<0.02	0.08	0.03	<0.01	<0.1
43	13.22	0.22	0.91	70.40	<0.1	0.37	0.19	0.04	13.06	<0.1	0.40	0.26	<0.02	0.07	0.03	<0.01	0.13
48	2.15	2.77	2.23	63.19	2.19	<0.1	0.77	3.66	20.41	0.47	0.70	0.92	0.03	<0.05	0.09	0.04	<0.1
49	0.92	3.03	2.61	62.02	1.88	0.24	0.12	5.28	21.45	0.30	0.82	0.94	0.02	<0.05	0.10	0.02	0.23
50	0.98	2.46	2.77	58.87	2.69	0.27	0.21	6.52	23.63	0.16	0.23	0.92	0.02	<0.05	0.06	0.01	0.16
51	1.08	2.47	2.85	58.95	2.54	0.25	0.23	6.43	23.63	0.28	0.23	0.93	0.02	<0.05	0.06	0.02	<0.1
52	0.84	3.12	2.21	60.43	2.02	0.28	0.10	5.50	23.08	0.32	0.86	0.87	0.02	<0.05	0.11	0.03	0.16
53	1.00	2.41	2.65	58.87	2.58	0.45	0.19	6.58	23.67	0.12	0.23	0.94	0.02	<0.05	0.06	0.02	0.18
54	0.80	2.96	2.43	61.88	1.87	0.20	0.11	5.46	21.85	0.33	0.81	0.93	0.02	<0.05	0.10	0.02	0.18
55	0.76	2.85	2.46	63.07	1.83	0.13	<0.1	5.32	21.12	0.33	0.81	0.95	0.02	<0.05	0.09	0.03	0.14
56	0.89	3.16	2.58	62.86	1.88	0.21	0.14	5.26	20.69	0.29	0.80	0.86	0.02	<0.05	0.09	0.03	0.19
57	0.93	3.09	2.64	61.96	1.82	0.20	0.11	5.34	21.62	0.32	0.76	0.85	0.02	<0.05	0.07	0.02	0.23
58	0.82	2.89	2.54	62.23	1.77	0.25	0.14	5.36	21.85	0.36	0.76	0.86	0.02	<0.05	0.09	0.02	<0.1
59	1.57	2.76	2.73	62.67	2.29	<0.1	0.57	4.22	20.50	0.39	0.69	0.92	0.03	<0.05	0.08	0.04	0.20
60	1.03	3.30	2.31	59.73	2.04	0.21	0.16	5.56	23.08	0.31	0.92	0.91	0.02	<0.05	0.11	0.03	0.28
61	1.29	3.00	2.55	58.21	2.13	0.22	0.28	4.76	25.43	0.28	0.54	0.82	0.02	<0.05	0.09	0.03	<0.1
62	8.55	5.30	3.22	64.97	0.85	0.28	0.63	4.07	10.72	0.11	0.06	0.77	<0.02	<0.05	0.43	0.01	<0.1
63	8.06	5.41	3.25	65.31	0.85	0.34	0.57	4.09	10.69	<0.1	0.06	0.75	<0.02	<0.05	0.48	0.02	<0.1
64	8.29	5.40	3.35	65.27	0.78	0.23	0.62	4.06	10.57	0.10	0.06	0.76	<0.02	<0.05	0.45	0.02	<0.1
65	8.40	5.42	3.24	65.12	0.94	0.19	0.60	4.05	10.52	0.18	0.06	0.77	<0.02	<0.05	0.46	0.02	<0.1

No.	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	ZnO	As <sub>2</sub> O <sub>3</sub>	SrO	ZrO <sub>2</sub>	BaO
66	8.30	5.36	3.23	65.44	0.90	0.26	0.60	3.99	10.45	0.11	0.05	0.76	<0.02	<0.05	0.49	0.02	<0.1
67	8.46	5.56	3.26	65.04	0.80	0.27	0.63	3.96	10.60	0.11	0.05	0.77	<0.02	<0.05	0.44	0.01	<0.1
68	8.17	5.43	3.31	65.18	0.87	0.27	0.62	3.93	10.68	0.12	0.06	0.77	<0.02	<0.05	0.50	0.02	<0.1
69	8.13	5.32	3.32	65.50	0.87	0.19	0.59	4.12	10.51	<0.1	0.06	0.77	<0.02	<0.05	0.45	0.02	<0.1
70	8.34	5.42	3.33	65.16	0.82	0.30	0.59	4.10	10.53	<0.1	0.05	0.76	<0.02	<0.05	0.46	0.02	<0.1
71	8.52	5.43	3.38	65.01	0.78	0.27	0.60	3.97	10.38	<0.1	0.06	0.76	<0.02	<0.05	0.50	0.02	0.19
72	2.16	2.84	2.56	60.81	1.82	0.46	0.36	5.10	22.06	<0.1	0.11	1.05	0.03	<0.05	0.11	0.02	0.41
73	8.38	6.11	2.21	66.35	0.83	0.22	0.42	4.24	9.89	<0.1	0.05	0.60	<0.02	<0.05	0.50	0.02	0.13
74	1.08	1.93	2.38	62.63	2.04	0.27	0.13	6.00	22.08	0.18	0.11	1.05	0.02	<0.05	0.05	0.01	<0.1
75	1.16	2.37	2.43	63.28	2.13	0.21	0.21	5.75	21.03	0.18	0.11	1.04	0.03	<0.05	0.05	0.01	<0.1
76	1.00	2.05	2.58	59.84	2.31	0.54	0.13	6.41	23.71	0.25	0.13	0.93	0.03	<0.05	0.06	0.01	<0.1
77	0.80	1.98	2.54	61.53	2.13	0.24	0.23	5.76	23.48	0.14	0.11	0.97	0.02	<0.05	0.05	0.01	<0.1
78	1.59	3.54	3.60	58.15	2.14	0.14	0.50	6.78	21.64	0.25	0.80	0.49	0.02	<0.05	0.06	0.02	0.24
79	7.09	4.88	1.92	66.48	1.34	0.18	0.73	4.31	11.88	0.12	0.04	0.53	<0.02	<0.05	0.46	0.02	<0.1
80	7.20	4.98	1.95	66.24	1.28	0.17	0.72	4.28	12.00	<0.1	0.04	0.53	<0.02	<0.05	0.46	0.02	<0.1
81	7.05	4.92	1.86	66.62	1.30	<0.1	0.70	4.31	11.95	0.11	0.04	0.53	<0.02	<0.05	0.46	0.02	<0.1
82	7.49	5.06	1.96	66.57	1.32	0.12	0.78	4.06	11.46	<0.1	0.05	0.53	<0.02	<0.05	0.46	0.02	<0.1
83	12.14	0.29	1.36	70.54	<0.1	0.21	0.25	0.31	12.32	<0.1	0.39	0.38	<0.02	0.14	0.03	<0.01	<0.1
84	11.64	0.31	1.21	70.72	<0.1	0.31	0.25	0.30	12.64	<0.1	0.37	0.36	<0.02	0.14	0.03	<0.01	0.14
85	11.91	0.28	1.27	70.39	<0.1	0.37	0.28	0.35	12.69	<0.1	0.38	0.37	<0.02	0.14	0.03	<0.01	<0.1
86	11.93	0.33	1.14	70.31	<0.1	0.37	0.31	0.36	12.74	<0.1	0.39	0.37	<0.02	0.14	0.03	<0.01	<0.1
87	11.81	0.36	1.13	70.17	<0.1	0.26	0.29	0.39	12.98	<0.1	0.37	0.36	<0.02	0.14	0.03	<0.01	0.24
88	12.08	0.27	1.14	70.37	<0.1	0.28	0.28	0.33	12.71	<0.1	0.38	0.37	<0.02	0.13	0.03	<0.01	0.20
89	12.17	0.27	1.13	70.33	0.15	0.29	0.28	0.34	12.60	<0.1	0.36	0.37	<0.02	0.13	0.03	<0.01	0.10
90	9.20	5.34	3.13	66.16	0.68	0.26	0.52	4.38	9.04	<0.1	0.05	0.69	0.02	<0.05	0.39	0.02	<0.1
91	9.68	5.56	3.14	66.20	0.79	0.25	0.50	4.06	8.55	<0.1	0.05	0.69	<0.02	<0.05	0.40	0.02	<0.1
92	9.51	5.30	2.95	65.99	0.67	0.30	0.52	4.48	9.00	<0.1	0.05	0.69	<0.02	<0.05	0.40	0.02	<0.1
93	9.20	5.21	3.18	66.17	0.74	0.28	0.53	4.45	8.88	0.13	0.05	0.70	<0.02	<0.05	0.40	0.02	<0.1
94	9.41	5.55	2.93	66.27	0.67	0.23	0.44	4.22	8.84	<0.1	0.05	0.70	<0.02	<0.05	0.40	0.02	0.19
95	9.55	5.60	3.05	66.43	0.63	0.33	0.46	4.21	8.39	<0.1	0.05	0.70	<0.02	<0.05	0.40	0.02	0.14
96	9.44	5.41	3.00	66.26	0.68	0.23	0.51	4.35	8.77	<0.1	0.05	0.70	<0.02	<0.05	0.40	0.02	0.12
97	9.53	5.52	3.09	66.18	0.73	0.19	0.50	4.22	8.65	0.18	0.04	0.69	<0.02	<0.05	0.39	0.02	<0.1



No.	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	ZnO	As <sub>2</sub> O <sub>3</sub>	SrO	ZrO <sub>2</sub>	BaO
98	9.36	5.52	3.17	66.11	0.60	0.30	0.47	4.33	8.74	0.19	0.04	0.70	<0.02	<0.05	0.40	0.02	<0.1
99	7.59	5.23	2.70	66.52	0.81	0.26	0.51	4.23	10.73	<0.1	0.06	0.62	<0.02	<0.05	0.45	0.02	0.20
100	7.62	5.16	2.85	66.75	0.80	0.29	0.50	4.06	10.76	<0.1	0.06	0.61	<0.02	<0.05	0.44	0.02	<0.1
102	9.19	5.33	3.05	66.28	0.66	0.28	0.50	4.37	8.91	0.13	0.04	0.69	<0.02	<0.05	0.40	0.02	0.12
103	9.46	5.42	3.03	65.98	0.91	0.27	0.44	4.34	8.87	<0.1	0.05	0.65	<0.02	<0.05	0.36	0.01	0.14
105	7.76	5.17	2.81	66.72	0.86	0.19	0.45	4.10	10.61	0.15	0.06	0.60	<0.02	<0.05	0.44	0.02	<0.1
106	7.62	5.21	2.86	66.76	0.95	0.32	0.47	3.99	10.51	0.12	0.06	0.63	<0.02	<0.05	0.44	0.02	<0.1
107	9.51	5.50	3.08	65.92	0.74	0.34	0.46	4.32	8.69	0.21	0.05	0.70	<0.02	<0.05	0.42	0.02	<0.1
108	9.62	5.45	3.07	66.06	0.73	0.17	0.49	4.36	8.71	0.14	0.05	0.70	<0.02	<0.05	0.39	0.02	<0.1
109	9.63	5.52	3.08	66.17	0.72	0.18	0.45	4.46	8.59	<0.1	0.05	0.70	<0.02	<0.05	0.39	0.02	<0.1
110	9.32	5.32	3.13	66.24	0.64	0.26	0.47	4.34	8.88	0.18	0.05	0.68	<0.02	<0.05	0.40	0.02	<0.1
111	9.50	5.55	3.14	66.11	0.75	0.31	0.49	4.28	8.52	0.15	0.04	0.70	<0.02	<0.05	0.40	0.02	<0.1



## **ENGLISH HERITAGE RESEARCH DEPARTMENT**

*English Heritage undertakes and commissions research into the historic environment, and the issues that affect its condition and survival, in order to provide the understanding necessary for informed policy and decision making, for sustainable management, and to promote the widest access, appreciation and enjoyment of our heritage.*

*The Research Department provides English Heritage with this capacity in the fields of buildings history, archaeology, and landscape history. It brings together seven teams with complementary investigative and analytical skills to provide integrated research expertise across the range of the historic environment. These are:*

- \* Aerial Survey and Investigation*
- \* Archaeological Projects (excavation)*
- \* Archaeological Science*
- \* Archaeological Survey and Investigation (landscape analysis)*
- \* Architectural Investigation*
- \* Imaging, Graphics and Survey (including measured and metric survey, and photography)*
- \* Survey of London*

*The Research Department undertakes a wide range of investigative and analytical projects, and provides quality assurance and management support for externally-commissioned research. We aim for innovative work of the highest quality which will set agendas and standards for the historic environment sector. In support of this, and to build capacity and promote best practice in the sector, we also publish guidance and provide advice and training. We support outreach and education activities and build these in to our projects and programmes wherever possible.*

*We make the results of our work available through the Research Department Report Series, and through journal publications and monographs. Our publication Research News, which appears three times a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities. A full list of Research Department Reports, with abstracts and information on how to obtain copies, may be found on [www.english-heritage.org.uk/researchreports](http://www.english-heritage.org.uk/researchreports)*

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